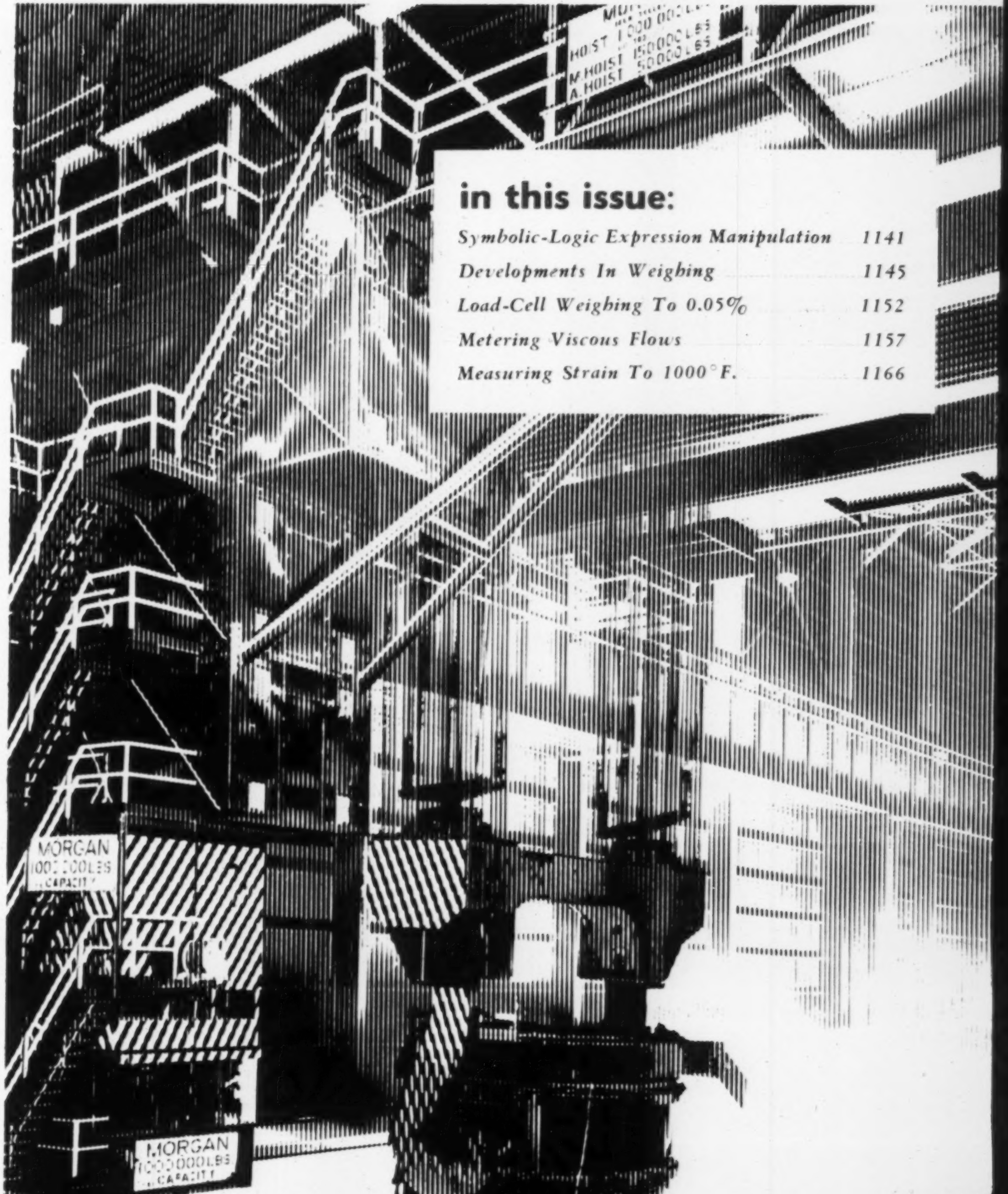
INSTRUMENTS AND CONTROL SYSTEMS

INCLUDING: INSTRUMENT MANUFACTURING • JOURNAL OF THE SCMA • SIMULATION COUNCIL NEWSLETTER

JULY
1960


MORGAN
1000000 LBS
CAPACITY
HOIST 1000000 LBS
M. HOIST 150000 LBS
A. HOIST 50000 LBS

in this issue:

Symbolic-Logic Expression Manipulation 1141
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Load-Cell Weighing To 0.05% 1152
Metering Viscous Flows 1157
Measuring Strain To 1000°F. 1166

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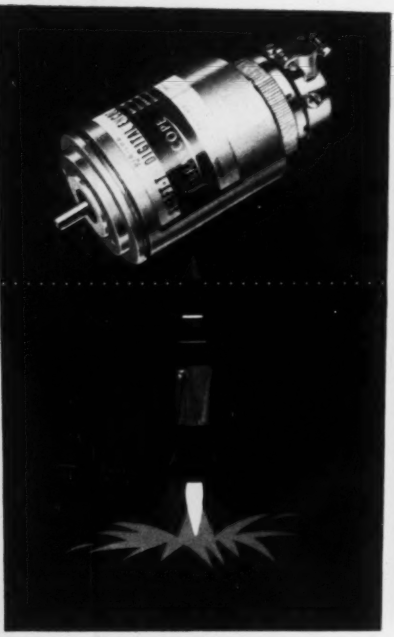

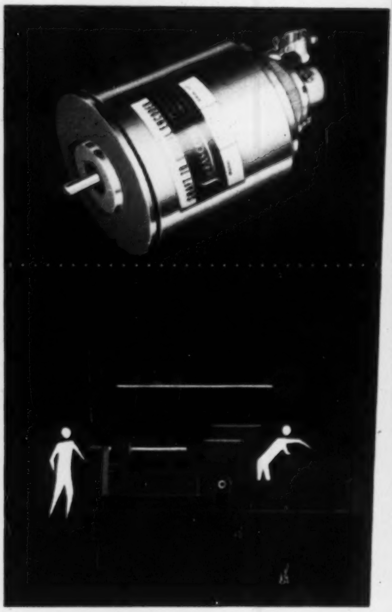

CODE OUTPUT	MODEL NO.	TOTAL CAPACITY	RESOLUTION PER TURN
SERIAL BINARY (LINEAR)	707 713 717 719	7 bits (128) 13 bits (8192) 17 bits (131,072) 19 bits (524,288)	128 128 128 128
BINARY (SIN-COS)	757* 758*	7 bits per quadrant 8 bits per quadrant	512 1024
BINARY CODED DECIMAL	723 through 735	2,000 through 360,000	200
GRAY	708	8 bits (256)	256
BINARY	740	10 bits (1024)	1024

*Available in hermetically sealed servo-driven package as Models 757-S and 758-S.

For information on career opportunities at Librascope, write Glen Seltzer, Employment Manager.

GP

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and many others in Automotive and Industrial Applications.

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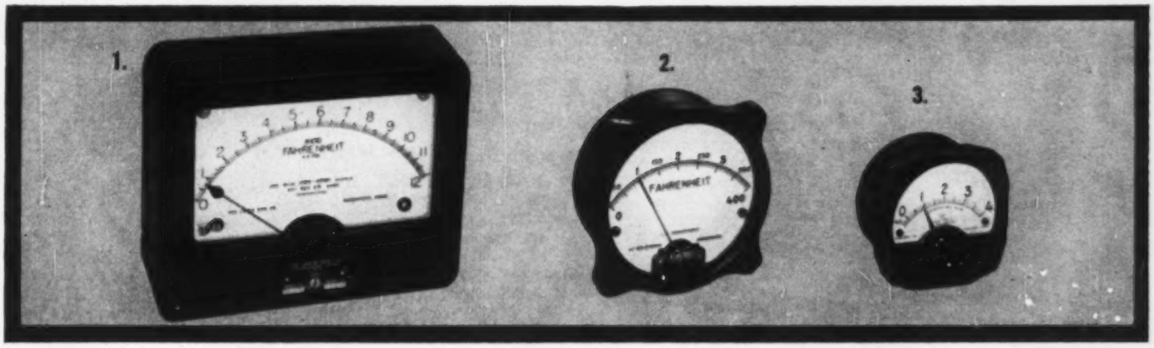
3. **Model 20B,** Three Inch Diameter Shielded Case

For use with I.S.A. Type Y, J, T, K or Chromel-Constantan Thermocouples.*



THE LEWIS ENGINEERING CO.

NAUGATUCK,
CONNECTICUT

*Hoskins TM.

CIRCLE 2 ON READER-SERVICE CARD

NEW INSTRUMENTS

by Sensitive Research

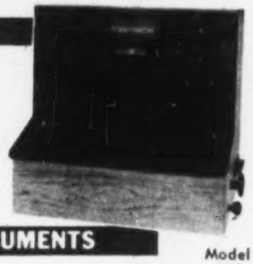
RF VOLTMETER CALIBRATOR

Model RFVC

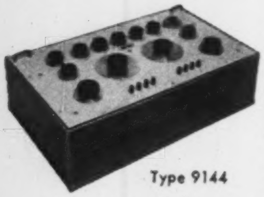
Model RFVC — Radio Frequency Self Checking RMS voltmeter for the certification of VTVM's from DC to 10 Mc. Accuracy .3% of full scale ± .2% frequency influence. Ranges .01/.1/1/3 V. Checks its own accuracy against a .05% stable internal standard source.

CALIBRATION CONSOLES

Model LTC — AC-DC/DC. Accuracy .05% of actual reading. Ranges .5 V. to 1111 V.; 1 Ma (2 Ma on AC) to 11.11 amps. Resolution .01%. Frequency range DC to 25 KC. Direct % Error Readout. Model LT-PS — AC power supply to full capabilities of console. Harmonic distortion less than .1%. Other consoles available.


Model LTC

DC POTENTIOMETERS


Type 9144

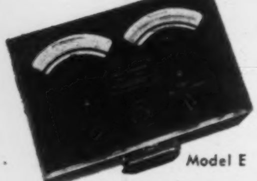
A new line of 6 figure instruments guaranteed 10X more accurate than any potentiometer commercially available today, having a subdivision of 1 part in 10^6 of the 1 volt setting and calibrated to be usable to an accuracy of ± .0002% or better. Absolute accuracy guaranteed to ± .001% nominal or better. Resolution excellent for comparison of saturated standard cells. Temperature controlled. High sensitivity Galvanometer, 4 terminal NBS Type resistors, ratio boxes and other primary standards available.

EXPANDED SCALE INSTRUMENTS

Model INCRE — Differential incremeter. A NEW .05% f.s. accurate expanded scale DC standard for rack panel mounting or portable use. Combines the high comparison accuracy of the differential instrument with a .005% stable source. Scale has an effective length of 63" or 70", and a resolution of 1000 divisions. Each 10% of any range is expanded over the instrument's actual 6.3" or 7" scale length. Direct reading. No balancing or nulling. Single or multirange combinations from 200 ua. to 30 amps. and 200 mv. to 1 kv.

Model INCRE

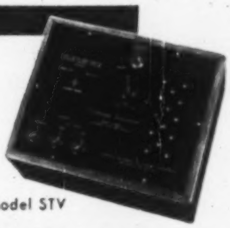
FORM FACTOR INSTRUMENT


Model E

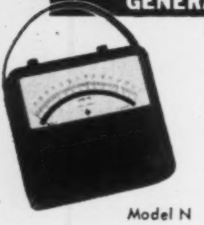
Model E — supplies a direct reading correction factor for instruments affected by non-sinusoidal wave form deviation. Indicates ratio of true RMS values to average, positive peak, and negative peak values. Determines the true RMS values of average and peak reading instruments that are used on a distorted wave. Accuracy: .2% between 25-500 cps.

DC VOLTAGE STANDARDS

Model STV — Nominal output 1.0000 V. and 1.0185 V. Accuracy ± .01%. Actual output certified within ± .001% and guaranteed stable within ± .005%. 115 V. 60 cps input. Unaffected by extremes of temperature, short circuiting, and vibration. Replaces the standard cell. OEM types available.


Model STV

GENERAL PURPOSE PORTABLES


Model N

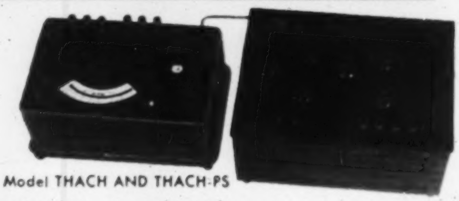
Model N—economically priced, stable and rugged .5% accurate DC current and voltage instrument. Long 6.1" scale. Employs a shielded "U" shaped magnet and not the common center core type characteristic of instruments in its price range. Model NP is for panel mounting. Model NSI is an AC version. All have molded bakelite cases and are available switch controlled.

AUTOMATIC OVERLOAD PROTECTION

Model 2 AP — AC-DC Polyranger. Thermocouple type. Automatically protected for overloads of at least 5000%. Accuracy: .75%. Ranges from 2 ma. to 1 amp. and 2 V. to 500 V. Sensitivity; 500 ohms/V. Diamond Pivoted. Other Polyrangers with as many as 88 ranges available.

Model 2AP

AC-DC LABORATORY STANDARD AND POWER SUPPLY


Model THACH AND THACH-PS

Model THACH — AC/DC Self Checking Volt-Amp Milliammeter. Accuracy ± .2% f.s. to 4 kc. Ranges — 10/20/50/100/200/500 ma.; 1/2/5 Amps; 1/2/5/10/20/50/100/200/500/1000 V. f.s. Checks its own accuracy against an internal standard cell. Model THACH-PS — special regulated THACH Power Supply (optional) automatically shuts off power to the THACH when switching ranges, reducing possibility of accidental overloads. Output is DC or 60 cps. (50-2500 cps. can be plugged in). Combination serves as a calibrator, measuring instrument, and general purpose power supply.

Primary and secondary standards for the accurate measurement or certification of AC-DC current, voltage, power, power factor, frequency and magnetic quantities. All electrical indicating instruments have hand-drawn mirrored scales and most are Diamond Pivoted, of course!

Not illustrated above, but available, are a complete line of portable and panel types including: • Wattmeters • Electrostatic Voltmeters • Peak Voltmeters • Thermocouple Instruments • Differentials • Ratiometers • Corrosion Instruments • Panel Instruments • Test Sets • Fluxmeters and accessories such as Shunts and Multipliers. All SRIC instruments have their certification directly traceable to the National Bureau of Standards and are unconditionally guaranteed.

NEW ROCHELLE, N.Y.

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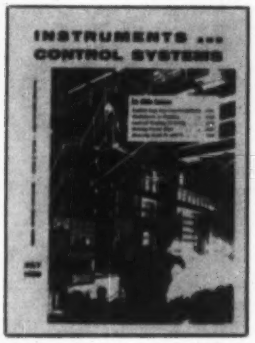
SENSITIVE RESEARCH INSTRUMENT CORPORATION

CIRCLE 3 ON READER-SERVICE CARD

INSTRUMENTS AND CONTROL SYSTEMS



WEIGHING INGOTS in terms of loss-of-weight of pouring ladle. For story see page 1152.

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NUMBER 7

JULY
1960

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INSTRUMENTS
AND
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JULY, 1960

PRINT ORDER THIS MONTH: 39,100

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The CMC 700 Series is the only major breakthrough in counting, timing and frequency measuring equipment in the past 10 years. Here is the first successful application of transistors to high frequency counting and timing. Transistors perform all the functions in CMC's 700 series that required 63 tubes in old style counting equipment. These are the most reliable counters ever made.

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By answering an obvious need for a completely new, up-to-date approach to counting and timing instrumentation, CMC has produced solid state instruments with greatly simplified circuitry, using logic "and" and "or" gates.

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Each 700 series instrument weighs only 27 pounds, measures 7 inches high, 17 inches wide, and 14 inches deep. Power consumption is a meager 46 watts, 1/10 the amount for vacuum tube models.

DO ALL THESE JOBS

Measure frequency from dc to 10 mc, time interval from 0.1 μsec, ratio 1 cps to 1 mc and unlimited multiple period selection. Frequency converters available for higher frequencies. The counter also generates time interval marker pulses from 1 μsec to 1 second. Data can be presented on standard decades or inline Nixie tubes. The 700 series will operate digital recording equipment, punches, inline readouts, and other data handling gear.

These Features, Too—Decade count-down time base—frequency divider circuits never need adjustment. Accuracy, ±1 count ±oscillator stability. Sensitivity, 0.25 v rms; input impedance, 25 k ohms/volt.

And The Price—Higher than vacuum tube models. But you can save the difference on down time in the first year. Model 727A Universal Counter-Timer, **$2,750**; Model 707A Frequency-Period Meter, **$2,575**. Model 757A Time Interval Meter, **$1,975.** Rack mount optional at no extra cost. All prices f.o.b. Sylmar, California.

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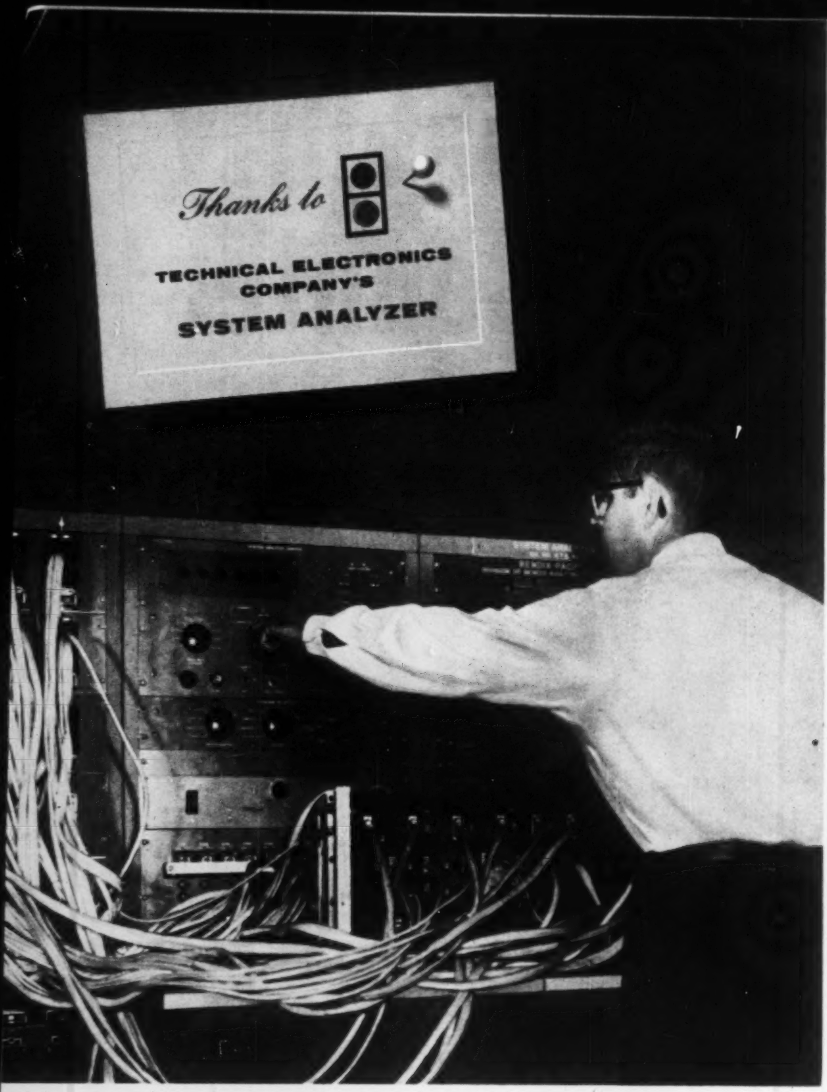

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The TEC "add-a-unit" System Analyzer specified by Bendix-Pacific will test continuity, hi-pot, leakage, voltage rating and impedance – automatically and in trouble shooting sequence. Faults are printed out for fast corrective maintenance.

The TEC System Analyzer replaces manual testing for all tests – not just continuity – meaning complete and reliable testing in a fraction of the time.

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LETTERS TO THE EDITOR

Editor, I&CS:

In reviewing the May issue of *INSTRUMENTS AND CONTROL SYSTEMS*, which featured temperature standardization and measurement, I noticed the freezing point temperature of silver was presented at different values. I call this to your attention so that any resulting inquiries may be readily answered.

In my article this temperature is given as 960.8°C, and in C. E. White's article as 960.5°C. On reading R. E. Wilson's article, the first impression is that 960.5°C is the correct value, but further reading of this reveals 960.50°C as the 1927 value and 960.8°C as the value adopted for the International Temperature Scale of 1948, which is the latest revision. The article by W. F. Roeser also gives the 960.8°C value.

I have enjoyed all these issues that have been featuring standards and look forward to the other issues on this subject.

S. C. Richardson
Electrical & Physical Standards Engineer
General Electric Company
Schenectady 5, New York

Our fault for letting the 1927 value slip through. Which proves the difficulty of ever trying to change anything!

Editor, I&CS:

Ref: news item in May issue.

Do you believe that the platinum bushings on the glass furnace are controlled by Hagan to ±¼°F at 2200°F?

W. H. Sayler
Specialty Sales Co.
Salt Lake City, Utah

This point is well taken—the sensitivity (resolution) of control is within ¼°, but the absolute accuracy cannot be 0.01% at this temperature. The Hagan Model P Amplifier used in the control loop has a resolution sensitivity of 0.1 microvolt. As the platinum-platinum-rhodium couple used (Type S) has a sensitivity of 7 microvolts per degree F, the amplifier has a possible resolution sensitivity of 0.01°F—the closed control actually maintains the temperature, as recorded on a deviation recorder with expanded scale, to within 0.25°F.

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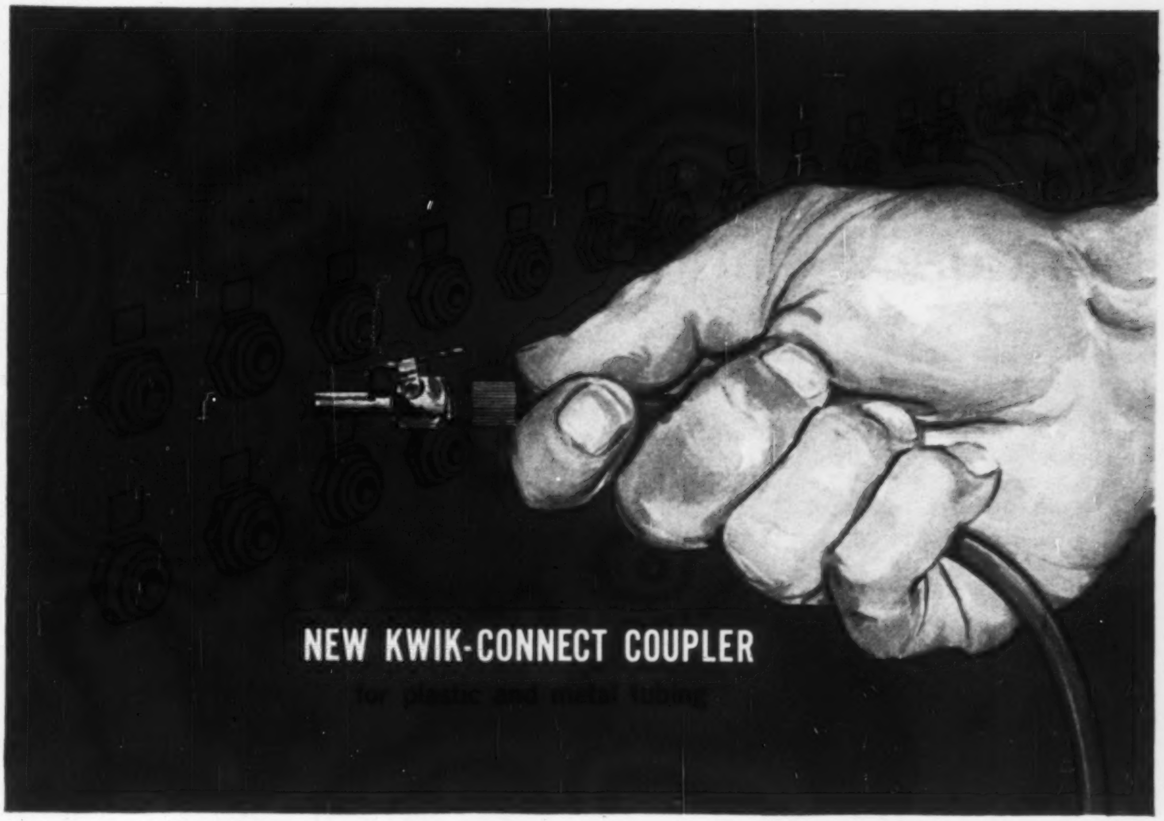
IMPERIAL
Engineering and Data File


NEW KWIK-CONNECT COUPLER
for plastic and metal tubing

PUSH...IT CONNECTS! *CLICK*...IT DISCONNECTS!

Making instrumentation connections with this new, polished-chrome Kwik-Connect Coupler is simple and fast. No pushing and fumbling with special rings or clamps. No complicated mechanisms. It's a snap!

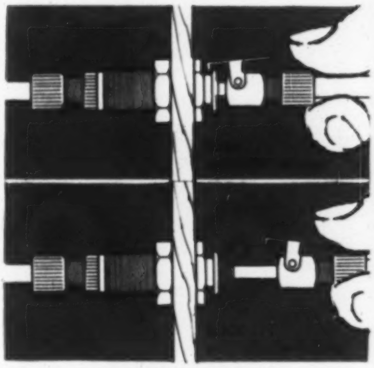
Just plug the parts together with a slight hand pressure. A unique cam action automatically moves the clip and locks the coupling in position. Inside, the flow is unrestricted through both the tube and coupling.

To uncouple, you simply press the spring-loaded clip. This disconnects the coupling and instantly seals off the flow. The patented shut-off feature is available in either the body end or the male connector end.

Other patented design features and the use of an "O" ring seal make Imperial's new Kwik-Connect Coupler a completely dependable connection far beyond the burst strength of polyethylene tubing.

LESS BULK, LESS WEIGHT

Only two moving parts — far simpler in design than ordinary quick couplers. Less bulky, lighter in weight. The 3/8" O.D. coupling weighs less than 3½ ounces; the ¼" O.D. coupling, less than 2 ounces. More dependable, too, because of a positive safety lock. It's the only quick-connect coupling that provides visual proof of a positive connection.



PROBLEM SOLVER

Kwik-Connect makes systems checking faster, easier. Ideal for pull-out consoles, test stands, panel boards, manifolding — eliminates the need for multiple gauges. Mounts on panels up to 1" thick.

Kwik-Connect Couplers are available two ways: tube-to-tube or tube-to-pipe thread. Tubing connections are Imperial Poly-Flo fittings which need only be finger-tightened, providing easier assembly, faster installation of polyethylene or other plastic tubing. Universal sleeve and nut available for nylon and metal tubing. Couplers fit bulkheads up to 1" thick.

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Simple knob adjustment eliminates temperature and gravity corrections. Forget about indexing the mercury well for each reading. W&T's specially graduated manometer scale automatically compensates for well level depression.

The Wallace & Tiernan FA-187 mercurial manometer also gives you:

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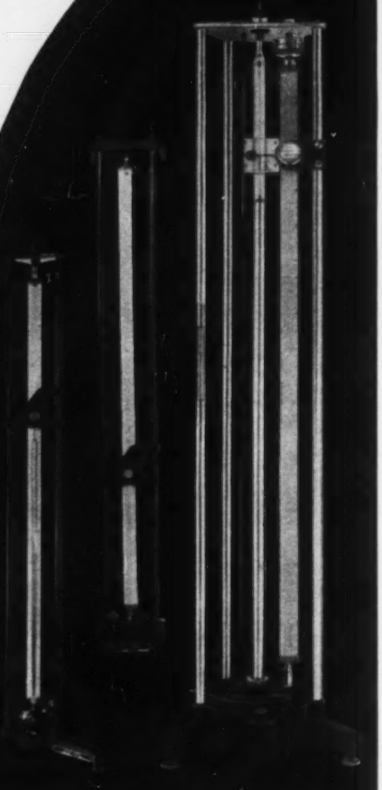
- ★ Range 0 to 31.5" Hg or equivalent
- ★ Readings to 0.005" Hg
- ★ Magnifying eye piece for exact reading
- ★ Magnetic vernier eliminates meniscus reading
- ★ Specially calibrated scale

Use the W&T mercurial manometers as calibrating standards for absolute pressure or easily modify them to perform as barometers, differential or vacuum indicators.

For further information, write Dept. A-128.48



WALLACE & TIERNAN INCORPORATED
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CIRCLE 7 ON READER-SERVICE CARD

Editor, I&CS:

Autonetics' design specialists considered your February article—"Quality Control in Bearing Manufacture and Vibration Measurement"—very timely in view of the increased emphasis being placed on system reliability and the necessity of predicting, with reasonable accuracy, the probability of a particular system's success.

Design Specialist A. M. Maschmeyer in our Reliability Engineering Section, in particular, noted that these requirements demand complete knowledge of the quality, failure rates, and failure modes of each component part of a system. He further notes that Autonetics believes vibration testing to be an excellent means of evaluating the internal geometry, cleanliness and composite quality of precision bearings. Vibration testing, furthermore, is considered to be an excellent quality control device for bearings as well as a means for evaluating the various facets of bearing reliability under dynamic conditions.

As so clearly pointed out in your article, however, each bearing manufacturer uses an instrument of his own design. Unfortunately, there is considerable variation in test levels and units of measurement between the different instruments. Because of the lack of coordination, our Mr. Maschmeyer notes that the bearing user is usually burdened with a single source of supply any time vibration levels are specified. The lack of standardization of vibration testers, he adds, limits the users use of these very desirable instruments.

Standardization of these instruments was undertaken by the American Ordnance Association of a few years ago, but lack of interest subsequently tabled the effort. Now, Mr. Maschmeyer strongly encourages reactivation of this standardization effort because such a standard would contribute much to the accumulation of failure data in standardized units and language and also materially aid the national reliability effort.

The standardization subject is discussed in much more detail in the enclosed article—"Why Not Standardized Functional Tests for Precision Ball Bearings?"—prepared by Mr. Maschmeyer. We submit this article for possible publication in your magazine.

James W. Carey
Autonetics
North American Aviation, Inc.
Downey, Calif.

This article is scheduled for our August issue.

Reader Inquiries

Ultraviolet Flame Detector

President of electronic engineering company developing a fire detection system is seeking ultraviolet tube to detect flame. A-646

Sewage Sump Level Controller

Technical supervisor of hydrocarbons manufacturer wishes to identify manufacturer of a float-operated pump controller for sewage sump, incorporating split cams with mercury switches, and indicating level on dial calibrated in feet and inches. A-645

Yellowness in Plastic

Manager of Control Dept. of large plastics manufacturer seeks photoelectric or optical equipment for continuous measurement of yellowness or haze of clear plastic sheet emerging from calender. A-644

Silver Mica Capacitors

Importer in Sweden is seeking silver mica capacitors "called Types DM20 and DM40 between 1 and 6000 pF in tolerances of ±1% and ±0.5%" or equivalent make. A-643

Electronic Suppression of Mechanical Noise

Owner of engineering company seeks means of electronic suppression of mechanical noise by a pickup, phase shift amplifier, and transducer which would introduce a signal at 180° phase shift. Frequency is approximately 1500 cps. A-642

MICRO-MODULE
UHF TRANSISTOR
PHOTO
SYSTEMS
HIGH RESOLUTION

"YALE" CAMERA

Custom-built precision camera systems for ultra-resolution of patterns . . . distortion free . . . on Kodak high-resolution plates, 1 x 3" or 2 x 10". Diamond Ordnance Fuse Laboratory type as described in literature with **increased** range and convenience . . . micron range tolerances.

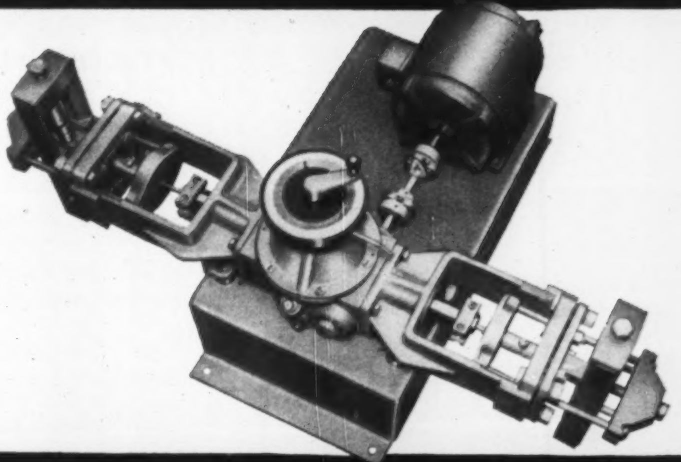
Write us with full details of your project. Delivery schedules now being processed.

Free 132 pg. Photo Equipment & Instrumentation Catalog. ICS 7/60

BURKE & JAMES, INC
321 S. Wabash Chicago 4, Illinois

CIRCLE 46 ON READER-SERVICE CARD

We Researched Over 15 Industries



Before We Designed This New Pump

From Maine to Texas we explored refineries, paper mills, pharmaceutical and chemical plants. Everywhere we found that metering operations—from pilot plants to proportional blending—were automated, efficient, ingenious. But there was room for an improved plunger pump. A pump that would give more flexibility and convenience in modern metering operations . . . positive accuracy and dependability in metering bland or harshly corrosive liquids against pressure.

Because it's designed around these critical needs, the new Wallace & Tiernan Series 200 Metering Pump fills the bill. Here's how:

Flexibility Drive units may be ganged to meter several liquids. One, two, or three liquid ends on one drive increase capacity and smooth out pumping pulsations. Six stroking speeds, several plunger diameters, and many liquid-end materials add further flexibility. "Stop-Adjust" and "Run-Adjust" models are available. On the latter, automatic stroke-length control, including ratio control, is easily achieved.

Convenience For different capacities or liquids, self-aligning liquid ends are quickly changed as complete units—a real convenience in pilot plant study. Bases for the Series 200 Pump may be steel plate, pipe, or structural shapes. A unique arrangement of eccentrics drives the plunger. This eliminates rocker arms and makes for the responsive, convenient stroke-length control industry needs.

Dependability The Series 200 Pump's design and materials mean resistance to wear and corrosion, less maintenance, and dependable operation. The drive is powered by a standard electric motor. Heavy ball bearings, forced-feed lubrication, and no cantilever bearing loads also assure long-lasting dependability.

Accuracy The Series 200 Pump meters accurately against up to 4,000 psi in the lower ranges (minimum 0.65 gph). And it meters any set amount, time after time, within ±1%—the kind of accuracy modern quality-controlled blending must have.

In every feature, the new Series 200 Pump is designed with modern industrial processing in mind. Component by component and feature by feature, you, the industrial user, called the shots. You specified the new W&T Series 200 Metering Pump.

For more on this user-inspired pump, write today to Dept. L-5.48.

WALLACE & TIERNAN INCORPORATED
25 MAIN STREET BELLEVILLE 9 NEW JERSEY

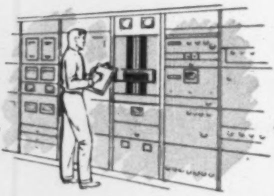
CIRCLE 8 ON READER-SERVICE CARD

the pb 250

a general purpose, microsecond computer for $30,000

COMPLETELY SOLID STATE

Outstanding features of the PB 250 include: ● MICROSECOND SPEED: Addition and subtraction require 12 microseconds. Multiplication takes 276 microseconds and division 252 microseconds. ● EXPANDABLE MEMORY: Minimum capacity of 1,808 words, expandable to 15,888 words. External core memory of 16,384 words available. ● COMMAND STRUCTURE: Versatile command list of 46 instructions. ● SIMPLE PROGRAMMING: Internally programmed, single address instructions, command indexing, and automatic double precision operations. ● INPUT-OUTPUT SYSTEMS: Automatic typewriter, paper tape reader, and punch standard. Complete range of peripheral equipment available. ● EXCEPTIONAL RELIABILITY: Conservative solid-state design, small component count, and absence of moving parts. ● SYSTEMS INTEGRATION: May be integrated into existing systems, on- or off-line. Ability to operate as universal format-to-format converter.



The design of the PB 250 enables it to be mounted as a systems component in 31 1/2 in. of a standard relay rack.

SPECIFICATIONS

TYPE
Serial, binary, internal program.

COMMAND STRUCTURE
Single address with index register.
46 commands.

OPERATION TIMES (22 bit word)

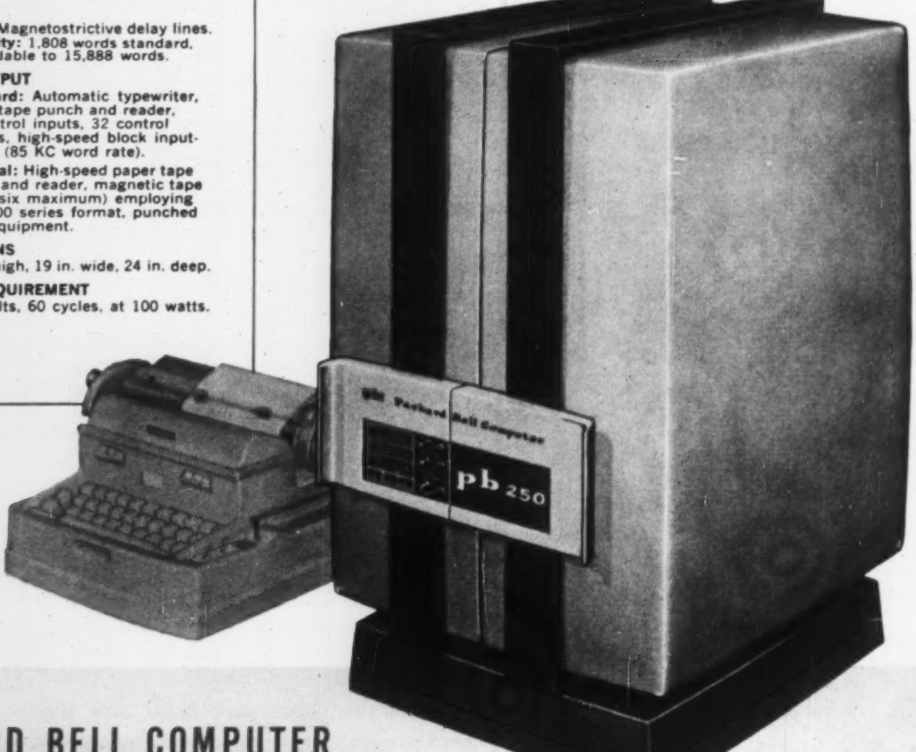
Add/subtract	12 μsec.
Multiply	276 μsec. (max.)
Divide	252 μsec. (max.)
Square root	252 μsec. (max.)

MEMORY
Type: Magnetostrictive delay lines.
Capacity: 1,808 words standard, expandable to 15,888 words.

INPUT-OUTPUT
Standard: Automatic typewriter, paper tape punch and reader, 30 control inputs, 32 control outputs, high-speed block input-output (85 KC word rate).
Optional: High-speed paper tape punch and reader, magnetic tape units (six maximum) employing IBM 700 series format, punched card equipment.

DIMENSIONS
30 in. high, 19 in. wide, 24 in. deep.

POWER REQUIREMENT
115 volts, 60 cycles, at 100 watts.



PACKARD BELL COMPUTER
A Subsidiary of Packard Bell Electronics
1905 Armacost Avenue, Los Angeles 25, California • GR 8-4247

● 3-7-60 PB

CIRCLE 9 ON READER-SERVICE CARD

BOOKS

Ingenious Mathematical Problems and Methods, by L. A. Graham, [c1959], Dover Publications, Inc., 180 Varick St., New York 14, N. Y., 237 pp., 8", paperbound $1.45. The author has accumulated 100 provocative and challenging mathematical problems of the high-school word-problem variety which offer a refreshing pass time in the originality of their solutions. These are selected in their shortest and most ingenious form.

CIRCLE 151 ON READER-SERVICE CARD

Mathematical Methods for Digital Computers, edited by Anthony Ralston and Herbert S. Wilf, [c1960] John Wiley & Sons, Inc., 293 pp., 10¼", clothbound $9.00. This reference text, containing 26 chapters written by experts who have been in close contact with the latest developments, offers mathematical analyses and derivations of commonly used techniques, and detailed discussions of the actual processing of complex mathematical and physical problems.

CIRCLE 152 ON READER-SERVICE CARD

The ASTRAGAUGE

Safe,
Accurate,
Easy Reading
For Pressures to 100,000 p.s.i.g.

New 6" diameter gauge is available in 12 ranges from 1,000-100,000 p.s.i.g. Features: multiple turn 316 stainless steel Bourdon element for longer life and greater accuracy; dial readings spread over 300°; expendable diaphragm-type back to relieve internal pressure; safety plate in front of element; no welding or soldering used on element or socket.

Write for complete data and prices.

ASTRA CORPORATION
HATBORO, PA., OSborne 5-1652

CIRCLE 10 ON READER-SERVICE CARD

New Concept in Viscosity Measurement

THE FERRANTI-SHIRLEY
CONE-PLATE VISCOMETER

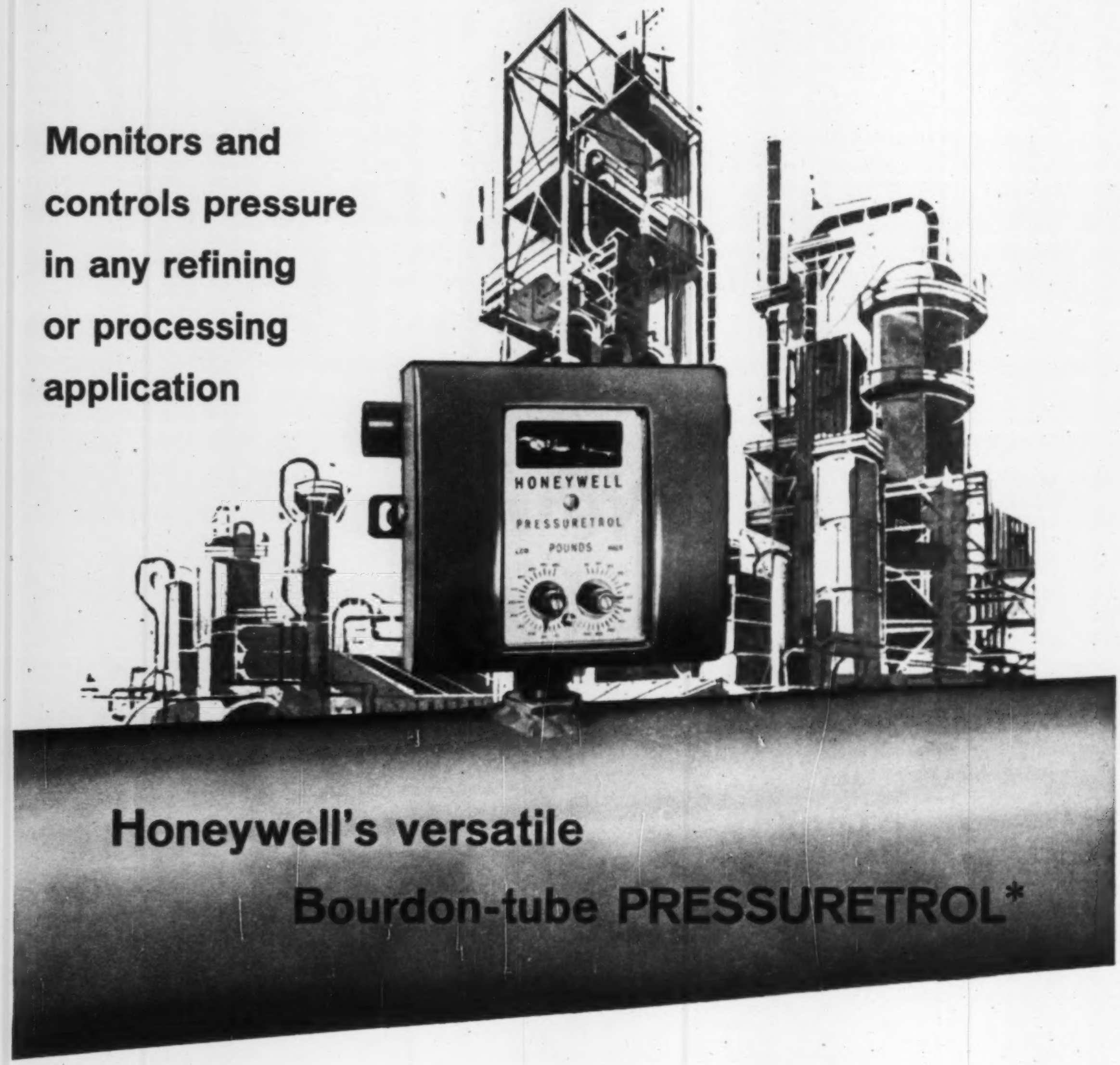
This advanced instrument enables the flow behavior of simple or complex fluids to be examined and evaluated with totally new standards of accuracy and precision. The instrument is particularly useful in handling the complex non-Newtonian fluids. Methods long used for characterizing these fluids have been subject to error. The cone-plate principle affords a constant rate of shear, speed accuracy within 0.2%; cone speeds continuously variable so as to give a shear rate range from 2 to 20,000 sec.-¹; direct reading of speed, full torque at all speeds, five sensitivities by selector switch.
A programmed control unit for use in conjunction with an X-Y recorder to permit automatic plotting of characteristics is also available.
Investigate this advanced viscometer and the new principle that brings a greater degree of accuracy to the examination of fluids under today's more critical and exacting requirements, both in laboratory and production control applications.

Write for literature.

F
FERRANTI

FERRANTI ELECTRIC, INC.
ELECTRONICS DIVISION
95 MADISON AVENUE HEMPSTEAD, N. Y.

CIRCLE 11 ON READER-SERVICE CARD



Monitors and controls pressure in any refining or processing application

Honeywell's versatile Bourdon-tube PRESSURETROL*

- **Suitable for all gasses, fluids and steam**
- **Ranges from 30 to 3000 psi**
- **Standard and explosion-proof models available**
- **FM, UL, FIA approved**

Model P428		Model P444	
Range (psi)	**Maximum (psi)**	**Range (psi)**	**Maximum (psi)**
30—300	375	20" vac—40	75
50—600	750	1—20	50
100—1000	1200	5—50	80
200—2000	2400	5—150	200
300—3000	2500		

Honeywell Pressuretrols precisely measure and control pressures of any fluid, gas or steam. They can be used to sound an alarm or control a valve, pump or compressor. These are heavy duty devices designed specifically for industrial use.

The Pressuretrol can be flush or surface-mounted on a panel, or installed directly on a pipe. Settings are made with one high and one low pressure knob conveniently located on face of the unit. The mercury switch can be easily seen through a protective glass window. Depending upon pressure range, bronze, stainless steel and beryllium copper Bourdon tubes are available. Choice of control to make on pressure rise or fall.

No matter what your pressure-control need, Honeywell can supply it for you. Call your local Honeywell office or write Honeywell, Dept. IC-7-41 Minneapolis 8, Minnesota. In Canada, write Honeywell Ltd., Seaside, Toronto 17.

See us in Sweet's 1960 Product Design File, Section 5b-Min.

*Trademark

Honeywell

H *First in Control*

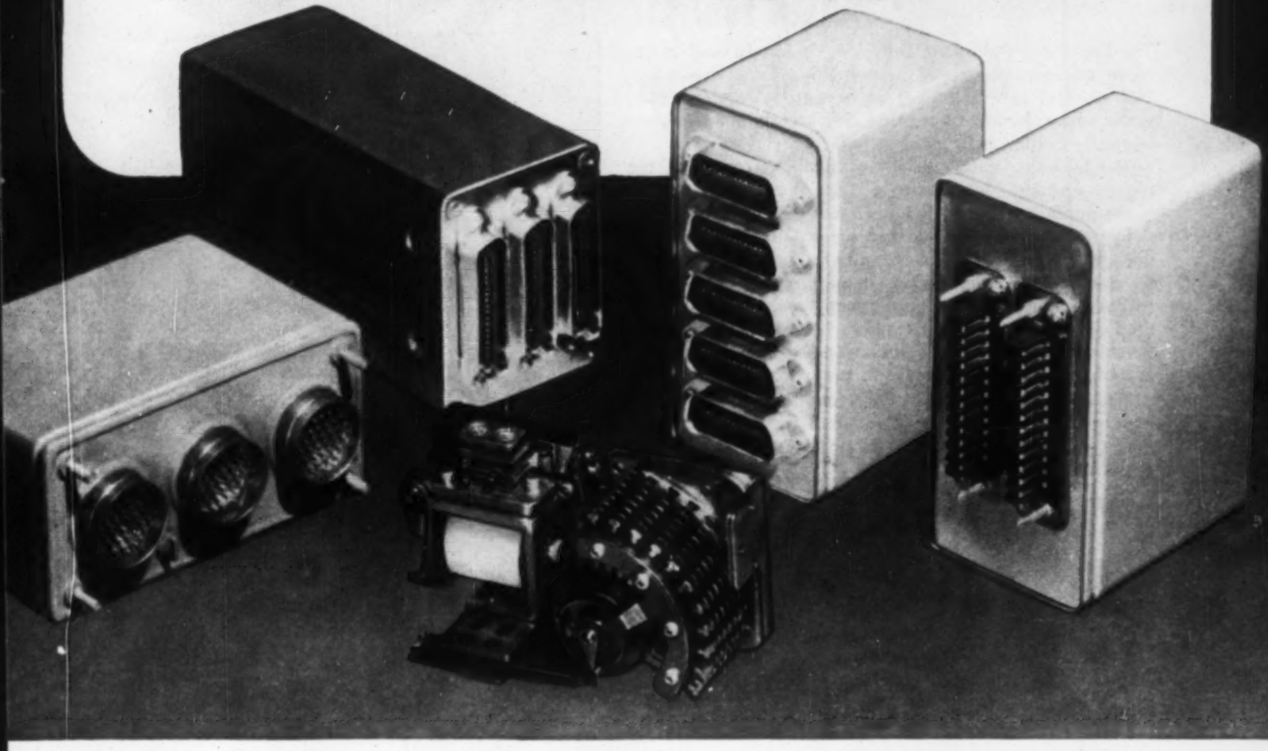
SINCE 1885

75th YEAR PIONEERING THE FUTURE

CIRCLE 12 ON READER-SERVICE CARD

NOW... from CLARE...

a new 10-Point Stepping Switch



for long life digital operation

Small, lightweight and capable of a minimum of over 100,000,000 operations,* the new CLARE Type 210 Stepping Switch is specially designed for digital operation. It is ideally suited as a component for sequence control, totalizing, sampling or single point selection. It transfers from Position 10 to Position 1 without special circuitry.

This new switch has all the improved features which have made the Type 211 an ideal component for complex switching requirements—long life, excellent capacity and freedom from maintenance. A wide variety of hermetically sealed and dust cover enclosures are available with terminals or connectors to suit the application.

Send for Bulletin CPC-6 for complete information. Address C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois; In Canada: C. P. Clare Canada Ltd., P. O. Box 134, Downsview, Ontario. Cable Address: CLARELAY.

*with twelve 10-point levels . . . 300,000,000 operations with four 30-point levels (properly lubricated and adjusted).

CLARE

Relays and Related Control Components

ELECTRICAL DATA

OPERATING SPEEDS—Self-interrupt speed: 60 sps at 25°C on nominal voltage. Remote impulse speed: 30 sps at 25°C on nominal voltage with 66% make impulse.

OPERATE & RELEASE TIME—Operate time: 20 ms at 25°C on nominal voltage. Release time: 10 ms at 25°C on nominal voltage.

OPERATE & RELEASE VOLTAGE—Maximum pull-in at 25°C is 75% of nominal voltage. Minimum dropout at 25°C is 3% of nominal voltage.

BREAKDOWN TEST—1000v, rms, 60 cps, is standard.

COILS—Coil resistances for typical voltages are shown below:

VOLTAGE Vdc	1-8 LEVELS OHMS	9-12 LEVELS OHMS
6	1.5	1.5
12	6	6
24	24	20
48	100	70
60	150	100
110	600	400

MECHANICAL DATA

OVERALL DIMENSIONS—Length (maximum)—4-5/16 in. Height (1C interrupter, 1C O.N.S.)—2¾ in. Width—from 1-5/16 in. for 3 levels to 2-13/16 in. for 12 levels.

NET WEIGHT—From one pound for 3 levels to 1½ pounds for 12 levels.

BANK CONTACT—Standard is phosphor bronze. Also available are coin silver or gold plated phosphor bronze.

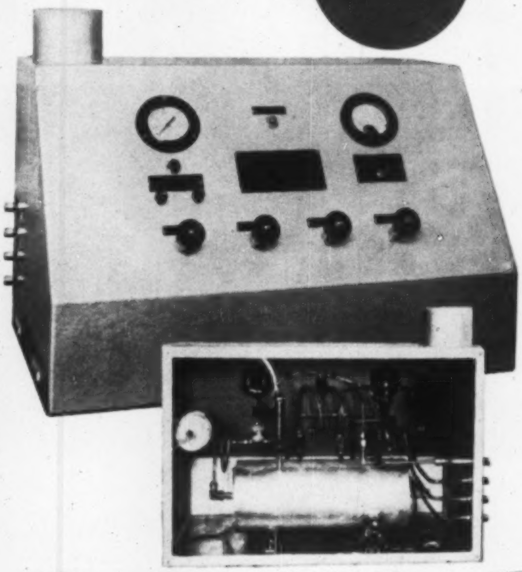
MAXIMUM BANK LEVELS & PILEUPS

Type of operation (points)	10	30
Bank levels maximum (electrical)	12	4
Interrupter springs	6	6
Off-normal springs	6	6
Number of ratchet teeth	30	30

WIPERS—Standard wipers are non-bridging phosphor bronze with coin silver and gold-plated phosphor bronze available in either non-bridging or bridging models.

Palladium Diffusion Purifier removes all impurities from commercial cylinder hydrogen

CHEMICAL DIVISION



The Engelhard Palladium Diffusion Purifier is used to remove all impurities from commercial cylinder hydrogen. This includes such impurities as oxygen, nitrogen, argon, water vapor, hydrocarbons and any others found in commercially bottled hydrogen.

The hydrogen purity achieved is, without question, the highest obtainable—no trace of impurities are detectable in the purified gas, by any known method.

Electrical circuit interlocks prevent palladium and hydrogen contacting at 150°C to form beta phase Pd-H2 system which is brittle and impervious. Impurities are not permitted to accumulate within the palladium tubes. Impurities are bled off continuously with a small hydrogen stream which is vented to a hood or a small burner. A check valve located in the pure product line prevents back flow into the tubes.

The Engelhard Hydrogen Palladium Diffusion Purifier is now manufactured in standard sizes for flowrates from 5 scfh up to 1000 scfh. Larger sizes are custom built to meet customer's requirement. Write for literature and price list.

CHEMICAL DIVISION • 113 ASTOR STREET
NEWARK, N. J.

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fine wire, thin foils, ribbon and tubing in noble metals and their alloys, for all applications.

BAKER PLATINUM DIVISION

The unique combination of properties of the noble metals continually recommend them for industrial applications. Our modern melting, wire drawing, rolling and heat treating equipment coupled with long experience in the field is at your service for production of standard and special items.

WIRES: Bare drawn wire of ductile materials down to .004" —High temperature thermocouple wires—High temperature furnace windings—Potentiometer and Resistance wires—Platinum clad tungsten wire.

FOILS: In platinum, palladium and gold down to .0001"—In iridium and rhodium as thin as .001".

TUBING: Seamless in platinum, palladium, gold and their alloys. Sizes from .018" with .004" wall up to 1½" with .042" wall.

For complete information write for our leaflets, "Fine Wire, Foils, Ribbons" and "Noble Metal Thermocouple Wire".

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PROMPT PRECIOUS METAL SCRAP RECOVERY SERVICE • ENGELHARD PROCEDURES RECOVER

FOR MORE INFORMATION ON PURIFIERS CIRCLE 14

FOR MORE INFORMATION ON NOBLE CIRCLE 15

BAKER CONTACT DIVISION

precious metal contacts for high-reliability

For high-reliability and long operating life, precious metal contacts in pure or alloyed forms of silver, platinum, palladium and gold are very definitely indicated. These contacts provide unmatched high resistance to atmospheric corrosion, deformation, arc erosion, binding and metal transfer. Baker precious metal contacts are supplied as wire, rod, sheet and in a complete line of fabricated forms. Facilities are also available for manufacture to your specifications. Write for Baker Contact catalog.

BAKER CONTACT DIVISION • 207 GRANT AVE., E. NEWARK
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ENGELHARD
INDUSTRIES, INC.
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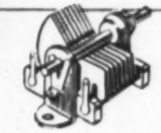
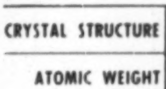
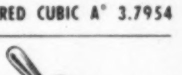
CHEMICAL DIVISION







CRYSTAL STRUCTURE	**FACE CENTERED CUBIC A° 3.7954**
ATOMIC WEIGHT	**102.91**
DENSITY	**12.44**
MELTING POINT	**1966°C**
COEF. OF LIN. EXPANSION	**8.19 X 10^{-6} 0°C, PER °C**
THERMAL CONDUCTIVITY	**(0°C) 213 C.G.S. UNITS**
REFLECTIVITY ELECTROPLATE	**78%. AT—620 MU**
HARDNESS ELECTROPLATE	**540-640 V.H.N. 20GRAM LOAD**

corrosion-resistant rhodium plating

The properties of Rhodium are particularly well-suited to many electrical and electronic applications. In general, Rhodium improves efficiency whenever a low-resistance, long-wearing, oxide-free contact is required. Rhodium plate assures low noise level for moving contacts, no oxide rectification, low and stable contact resistance. Rhodium plated slip rings and commutators show negligible wear. The positive action of plated contacts subjected to long periods of inactivity emphasizes the efficiency of Rhodium for safety alarm contacts. Excellent protection against atmospheric corrosion is obtained for printed circuits by plating Rhodium over nickel to assure long wear and low noise, or Rhodium over Silver to protect against tarnish and corrosion.

In the realm of high and ultra-high frequency the high resistance of Rhodium to surface corrosion under all atmospheric conditions is specially useful. Oxide-free contacts eliminate partial rectification and unwanted signals.

Call for technical assistance or write for literature.

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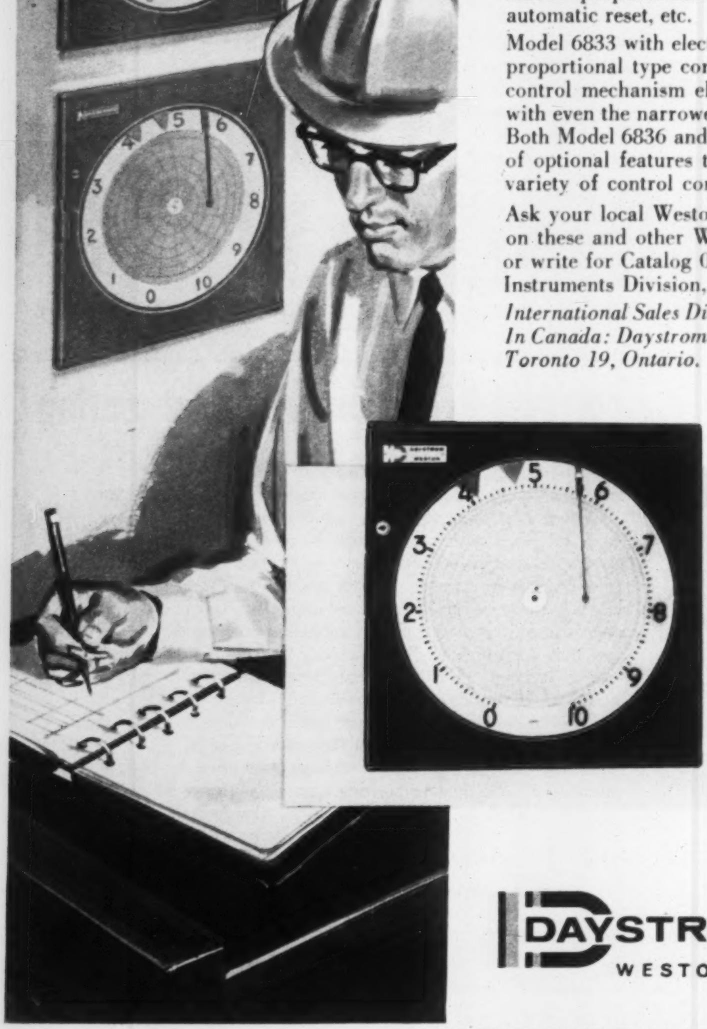
100% OF ASSAYED PRECIOUS METAL CONTENT • IRVINGTON-BAKER REFINING DIVISION

FOR MORE INFORMATION ON CONTACTS CIRCLE 16

FOR MORE INFORMATION ON PLATING CIRCLE 17



DESIGNED FOR RELIABILITY THROUGH
WESTON "UNITIZED" CONSTRUCTION

WESTON CIRCULAR CHART RECORDERS OFFER MAXIMUM FLEXIBILITY OF CONTROL FORMS

Two Weston Recorder-Controllers—Model 6836 and Model 6833—give instrument engineers needed versatility for effective process control. And, of course, both feature Weston accuracy—within ±¼% of span or ±.025 mv.

Model 6836 provides 3 to 15 psi pneumatic output for final control elements, and is available in a complete range of pneumatic control forms, such as on-off, differential gap, narrow proportional band, proportional band with automatic reset, etc.

Model 6833 with electric control is available in contact or proportional type control. Unique design of the control mechanism eliminates chatter due to vibration with even the narrowest differential.

Both Model 6836 and 6833 are designed for the addition of optional features to accommodate a great variety of control configurations.

Ask your local Weston representative for complete information on these and other Weston instruments for industry, or write for Catalog 08-101-A. Daystrom, Incorporated, Weston Instruments Division, Newark 12, New Jersey.

International Sales Division: 100 Empire Street, Newark 12, N. J.
In Canada: Daystrom Ltd., 840 Caledonia Rd.,
Toronto 19, Ontario.

Model 6836 (illustrated) and Model 6833 are supplied in potentiometer or Wheatstone Bridge types. Scale: 320° concentric, 33.86" long. Chart speed: 1, 4, 8, 12, 24, 48 hours or 7 days per revolution.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION

CIRCLE 64 ON READER-SERVICE CARD

Traveling Instrument Exhibit

NEW YORK, N. Y.—Six of the nation's leading instrument manufacturers will stage five exhibits around metropolitan New York and Philadelphia via a traveling technical show, which will be officially known as the Electronic Instrument Manufacturers' Exhibit. The project, under the sponsorship of *FXR, Inc.; General Radio Co.; Lambda Electronics Corp.; Panoramic Radio Products Co., Inc.; Sensitive Research Instrument Corp.;* and *Tektronix, Inc.* comprises more than 40 products which complement and are scientifically related to each other. The exhibit will start October 5 in Garden City, L. I., will go to Norwalk, Conn.; Poughkeepsie, N. Y.; Cedar Grove, N. J.; and will wind up October 20 in Philadelphia-Moorestown, N. J. Picture shows an informal get-together of the exhibit's planners.

Seated l. to r. are: **Bernard Schlessel,** pres, Panoramic Radio; **William D. Marshall,** v-p sales, FXR; **Simeon Weston,** exec v-p, Lambda Electronics; and **Marvin Steinberg,** v-p sales, Sensitive Research Instrument. Standing l. to r. are: **Tore N. Anderson,** exec v-p, FXR; and **William R. Saylor,** sales mgr., General Radio.

Fluid Controls Institute Elects Fred E. Weldon President

WHITE SULPHUR SPRINGS, W. VA.—At the Spring Meeting, held at The Greenbrier, May 11-14, 1960, Fluid Controls Institute, Inc. elected its officers for 1960/61.

Fred E. Weldon of General Controls, Skokie, Ill. was elected president; *Robert F. McCormick,* Automatic Switch Co., first vice-president; *Eric A. Bianchi,* Mason-Neilan Div. of Worthington Corp., second vice-president; *Paul K. Rogers, Jr.* Skinner Electric Valve Div., The Skinner Chuck Co., treasurer; and *Samuel J. Reid,* Barnes & Jones Inc., corporate secretary.

SENSITIVE RESEARCH INSTRUMENT CORP. has signed a sales agreement with Tinsley Instruments (Canada) Ltd. to market the Tinsley line of electrical primary standards in the United States as its new "Commander" line.

MESUCORA, the first International Exhibition on MESUrement, COntrol, Regulation, and Automation to be held in France, is scheduled for May 9 to 17, 1961 at the Exhibition Hall of C.N.I.T. in Paris. Address MESUCORA, Secreteriat General, Palais du C.N.I.T., 20 rue Carpeaux, Puteaux (Seine), France for more information.

Standardizing Laboratory

BURBANK, CALIF.—Under recently revised regulations of the Department of Defense all prime contractors and their sub-contractors must demonstrate that their precision measuring instruments have been compared to and referenced to the primary standards in the National Bureau of Standards. This process is called "traceability of standards" and has been compared to tracing the continuity of an electrical circuit from an outlet to its source.

Metrolonics, Inc., a newly founded independent standardizing laboratory, will supply to industry such services. To assure the highest quality of precision measurement standards, Metrolonics has constructed an environmentally-controlled laboratory that maintains a constant temperature of 68°F and a constant 40% humidity 24 hours a day. The laboratory contains the finest precision measuring instruments in the world including German-made Zeiss Interference Comparator, a Zeiss Universal Measuring Machine, a Cleveland Micro-Ac calibrated to read one-millionth and one-half millionth of an inch, and a Pratt & Whitney Internal Comparator.

More information may be had from Meletronics, Inc., 2201 N. Hollywood Way, Burbank, Calif.

CIRCLE 150 ON READER-SERVICE CARD

HICKOCK ELECTRICAL INSTRUMENT CO., recently celebrated its golden anniversary. At a dinner *Richard Rimbach,* publisher of INSTRUMENTS & CONTROL SYSTEMS related the company's fifty years of contribution to the science of instrumentation and presented a memorial plaque honoring the late founder to *Mrs. Robert D. Hickok, Sr.*

What's YOUR Portable Power Problem?

BURGESS has more than 5000 battery types to choose from:

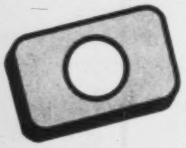
ZINC-CARBON
NICKEL-CADMIUM MERCURY
WATER-ACTIVATED

each with the highest measure of uniform dependability! This is why 2 of 3 electronic engineers specify

BURGESS BATTERIES

BURGESS
P6
ACTIVATOR
for TRANSISTOR CIRCUITS

BURGESS
IS THE MOST COMPLETE ONE-SOURCE LINE OF *Portable Power!*



EXCLUSIVE WAFER CELL CONSTRUCTION

. . . offers compactness, long shelf life, exceptional service life. A 30% increase in battery life at no increase in size.

TRANSISTOR ACTIVATORS

Burgess Activator Batteries for transistor circuits are smaller and more compact in size! Yet they deliver 30% more power because of the patented "Wafer-Cell" construction! Burgess Activators give you compact power, uniform performance, longer shelf life . . . all combined with modern packaging.

RESERVE BATTERIES

High energy output in a compact power source. Can be stored dry for years! Activated only when immersed in water. No handling of dangerous electrolyte, no spilling or leaking! Wide range of efficient operating temperatures. Designed for your specific applications.

MERCURY ACTIVATORS

Burgess constructional features provide *uniform quality and dependable service!* Burgess exclusive patents offer sealed-in-steel protection, wide temperature range efficiency, controlled venting, patented inner cell connector, and flat discharge curve.

SEALED NICKEL-CADMIUM BATTERIES

A secondary rechargeable battery system which delivers high energy output from a small package! Hermetically sealed-in-steel cells eliminate annoying maintenance and addition of liquids. Can be recharged many times, by trickle or quick charge, for long lasting economical power!

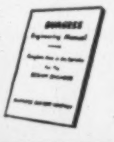
Check with your Burgess Distributor for complete local stocks of fresh BURGESS BATTERIES! Or your distributor can order from Burgess the special battery needed for your specific application!

FREE DESIGN SERVICE

For special applications, skilled Burgess Engineers offer you a FREE battery design service. Burgess will manufacture the exact battery to fit your needs, regardless of quantity required.

NEW ENGINEERING MANUAL

New 100-page dry battery handbook now available! Engineers engaged in the design of battery-powered equipment are invited to write to Burgess Battery Company, Dept. ICS Freeport, Ill., to secure a copy. Others may buy the manual for $1.00.



BURGESS BATTERY COMPANY
DIVISION OF SERVEL, INC.
FREEPORT, ILLINOIS

CIRCLE 19 ON READER-SERVICE CARD

STOCK REPORT

Further information may be obtained from the Research Department, Bache & Co., 36 Wall Street, New York 5, N. Y.

NEW YORK EXCHANGE

PRICE RANGE FOR 1960 THRU JUNE 16, 1960

	High	Low	Price As Of 6/16/60
ACF Industries	52	41 1/8	47 3/4
Aeroquip Corp.	40 5/8	30 3/4	31 1/8
Allis Chalmers	40	28 3/8	29
American Chain & Cable	51 3/4	44	47 7/8
Amer. Mach. & Foundry	74 3/4	49 1/2	71
Amer. Mach. & Metals	58 1/4	44 1/2	56 3/4
American Optical	62 3/4	43 1/4	62 3/4
Amer. Tel. & Tel.	96 1/8	79 7/8	89 1/8
Ampex Corp.	42 1/4	30 1/2	37 1/2
Bausch & Lomb Optical	58 7/8	34 1/2	57 1/4
Beckman Instruments	96 1/4	62 1/2	96 1/4
Bell & Howell	57 1/2	37 5/8	56
Bendix Aviation	74 1/2	57 1/2	67
Boeing Airplane	32 3/4	23	26 3/8
Bullard	17 7/8	11	13 3/8
Bulova Watch	18 7/8	14 1/8	15 1/4
Burroughs	40 3/8	28 3/4	38 3/8
Carborundum	49 7/8	41 1/4	45 1/2
Cinn. Milling Machine	38 1/2	28 5/8	30
Clevite	71 3/4	42	69 1/4
Columbia Broadcasting Sys.	45 1/4	36 5/8	44 1/2
Consol. Electronics	55	42 1/4	56 5/8
Corning Glass	186	124	177
Curtiss Wright	31 1/8	16 1/2	17 7/8
Cutler-Hammer	96	82	90
Daystrom	49 3/8	35 3/4	46 1/2
Douglas Aircraft	42 3/8	28	29 5/8
Eastman Kodak	136 1/4	94	127
Eaton Mfg.	46 7/8	33 1/4	34 3/8
Electric Auto-Lite	54 1/2	44 1/2	47
Elgin Watch	18 3/8	11 1/2	17 1/4
Emerson Electric (new)	49 1/2	33	49
Food Mach. & Chem.	56 3/8	44 1/2	55
Garrett	54 7/8	44	45 7/8
General Controls	29 5/8	18 1/2	24 1/8
General Dynamics	53 3/8	38	43 3/8
General Electric	99 7/8	84 3/8	93
General Instrument	43 1/8	22 1/2	44 1/2
General Mills	31	23 7/8	26
Gen. Precision Equip.	65 3/8	44 1/4	64
Gen. Railway Signal	36 7/8	27 1/2	34 1/2
Gen. Tel. & Elect. (new)	37 1/8	27	31 1/2
General Time (new)	33 1/8	23 3/4	26 3/8
General Tire & Rubber	81 3/8	55 7/8	63 1/8
International Bus. Mach.	542 1/2	407 1/4	529
Internat'l. Tel. & Tel.	46 3/4	32	44 5/8
I-T-E Circuit Breaker	44 1/4	21 7/8	23 3/4
Lear Inc.	21	13 5/8	21
Litton Industries	90	57 5/8	89 3/4
Lockheed Aircraft	32 7/8	18 5/8	20 1/8
Magnovox	55	31 3/4	50 3/4
Mallory	48 1/2	40 3/8	46 3/8
Minneapolis-Honeywell	178 3/4	123 5/8	172
Minnesota Mining & Mfg.	85 1/2	65	85 1/2
Motorola	194 1/4	140	181
National Acme	54 3/4	47	50 1/4
National Cash Register	70 7/8	55 3/4	67 1/4
Neptune Meter	34 3/8	27 1/2	30 1/2
North American Aviation	41 1/4	29 5/8	37 1/4
Northrop Aircraft	37 3/4	24 3/4	36 7/8
Otis Elevator	49 1/2	36 3/4	50 3/4
Philco Corp.	38 1/4	26 3/8	31 1/4
Radio Corp. of America	78	59 1/2	75
Raytheon Mfg.	53 3/8	35 1/2	42 1/4
Reliance Electric	68 5/8	47 3/4	65
Rheem Mfg.	28 7/8	18 1/2	21 3/4
Robertshaw Fulton	55	43	47 1/2
Royal Mc Bee	21 3/8	15 1/8	17 1/8
Sangamo Electric	21 1/2	17 1/2	17 7/8
Siegler Corp.	43	29 1/4	40
Sperry Rand	26 1/4	20 1/8	23
Square D	37 7/8	28 1/8	31 3/4
Standard Coil Products	23 3/8	12 5/8	24 3/4
Starrett (L.S.)	20	16	18
Stewart-Warner	33 1/2	23	32 1/2
Talautograph	10 1/4	6 7/8	8 1/4
Texas Instruments	256 1/4	154	243 3/4
Thompson-Ramo-Wooldridge	67 1/2	46 7/8	63 1/2
Tung-Sol Electric	40 1/2	31 1/8	37
Underwood Corp.	43 3/4	24 3/4	40 1/4
Union Carbide Corp.	148 1/2	126 1/4	136
United Shoe Machinery	64 3/8	50	58 1/2
Varian Associates	63 1/2	39 3/4	63 1/2
Wallace & Tiernan	56 1/2	41	56 1/2
Western Union	57	41 3/4	48 3/8
Westinghouse Air Brake	32 5/8	25 1/8	30 1/4
Westinghouse Electric	65	45 1/2	62 7/8
Worthington Corp.	66	50 1/2	53 1/4

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(1) Not Traded - Bid & Asked

These prices and price ranges are given as printed in the Wall Street Journal.

AMERICAN STOCK EXCHANGE

PRICE RANGE 1960 THRU JUNE 16, 1960

	High	Low	Price As Of 6/16/60
American Meter	52	44	45 1/4 Bid 45 7/8 Asked
Aro Equipment	25 1/4	19	24 1/8
Barry Controls "B"	25 1/2	16 1/4	21 3/8
Belock Instruments	19 3/4	13 1/8	21
Benrus Watch	7 1/2	5 3/8	6 3/8
Breeze Corp.	8 5/8	5 1/8	5 3/8
Clark Controller	23 5/8	20	22
Clarostat Mfg.	15 7/8	9 7/8	13 7/8
Clary Corp.	10 3/8	6 3/4	8 3/4
Cubic Corp.	67	48 1/2	57 3/4
Du Mont Laboratories	11 3/4	6 1/2	11 3/8

Continued on page 1088

150
200
250
H
LOW
HIGH

Never before such precise temperature control at this price!

$120 (SENSOR EXTRA)

Honeywell's new Resistance Bulb Controller responds to temperature changes as small as 0.1°, yet is modestly priced.

Honeywell's new R7087 temperature controller is a precision instrument designed for industrial use wherever temperatures must be precisely controlled: in packaging and plastics processing; plating tanks; annealing, bakery and paint-drying ovens; and in laboratory applications. Unusual flexibility is gained through a wide choice of sensors making ranges from −150° to +1400° F. possible. Centigrade scales are also available.

The new transistorized controller compensates for ambient temperature variations. Sensor connections of regular 18-gauge copper wire may be used up to 300 feet without sacrificing accuracy. Time proportioning with adjustable cycler timing is provided.

Panel lights indicate when unit is below, on or above set point. Controller can be surface-or flush-mounted, features illuminated dial. Other models are available with position proportioning.

For further information, call your local Honeywell office. Or write, Honeywell, Minneapolis 8, Minnesota. In Canada contact Honeywell Controls Limited, Toronto 17, Ontario.

75th YEAR PIONEERING THE FUTURE

Honeywell

H HONEYWELL First in Control SINCE 1885

CIRCLE 20 ON READER-SERVICE CARD

What's Your Line?

- Electronics
- Ceramics
- Computers
- Instrumentation
- Missiles
- Medical Equipment

Patent Pending

Protect your equipment against SHOCK and VIBRATION with this Model 707 TWIN-RACK.

This protection is provided for sensitive and delicate equipment by the pneumatic system of the Model 707 TWIN-RACK —the only console with the "built-in shock absorbers."

Model 707 TWIN-RACK's Floatation System literally keeps equipment "riding-on-air" thus prolonging the life of any wheeled instrumentation.

Model 707 TWIN-RACK will accept two 19-inch panels in a butt arrangement as shown or a single 38-inch panel on either side. Overall dimensions:

Height: 36-inches
Depth: 24-inches
Length: 41-inches

Also available is the Model 606 RACK-CADDY with a unique elevator system.

Write for further details

ESCOTRONICS

7000 Vine Street
La Grange, Illinois

Any and all sizes built to your specifications

CIRCLE 21 ON READER-SERVICE CARD

PHILADELPHIA
THERMAL CONTROLS AND THERMOMETERS

Specify! THE BEST

A half century of experience is back of every instrument we make. You get assured accuracy and long dependable performance when you specify "Philadelphia." Our specialized staff will be glad to discuss your problem in our field.

SEND FOR CATALOG 110

Since 1905

PHILADELPHIA THERMOMETER CO.
4401 N. Sixth St. • Philadelphia 40, Pa.

CIRCLE 22 ON READER-SERVICE CARD

AMERICAN STOCK EXCHANGE

continued from page 1086

Dynamics Corp. of Amer.	13 3/4	10 1/4	11 1/8	
El-Tronics	1 7/8	1 1/8	1 1/4	
Electronics Corp. of Amer.	19 1/2	8 1/8	16 3/4	
Fairchild Camera & Instrument	182	110 1/4	177 1/2	
General Transistor	31 3/8	18 5/8	28 3/8	
Giannini Controls	58 1/2	41 3/4	55 3/4	
Globe-Union	34 3/4	25	31 1/2	
Hazeltine Corp.	31 1/2	23	29 1/4	
Internat'l. Resistance	39 3/8	18 1/4	36 3/4	
Loral-Electronics	66	34 5/8	66	
National Research	23 1/8	14 7/8	18 5/8	
New Haven Clock	2 7/8	1 3/8	1 1/2	
Nuclear Corp. of Amer.	3 3/8	2 1/4	2 5/8	
Philips Electronics, Inc.	44	31 1/2	42 1/2	
Pneumatic Scale	59 3/4	39 1/4	40 42	Bid Asked
Polarad Electronics	64 1/4	30 1/2	62 1/4	
Servo Corp. of Amer.	24 1/2	14 1/4	14 1/8	
Servomechanisms	15 1/8	8 1/8	14 1/8	
Statham Instruments Inc.	40 1/4	27 1/8	39	
Textron Electronics	15 3/4	11 1/4	14 14 1/4	Bid Asked
Victoreen Instrument Co.	14 1/4	9 3/4	12	
Waltham Prec. Instr. Co.	3 1/2	2 3/4	3	

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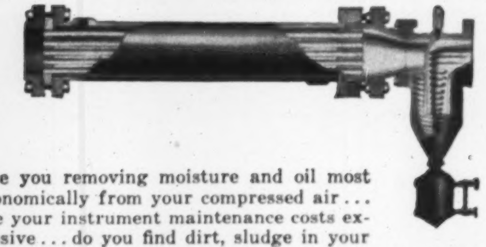
(1) Not Traded - Bid & Asked

These prices and price ranges are given as printed in the Wall Street Journal.

OVER THE COUNTER

	Quotation As Of June 15, 1960 Bid	Asked
Aerovox Corp.	11	11 3/8
Argus Corporation	29	29 3/4
Black Sivalls & Bryson Inc.	12	12 5/8
Eitel Mc Cullough	28 1/4	28 7/8
Electro Instruments	56	57 3/4
Electronics Associates	24 1/2	25 1/2
Erie Resistor Corporation	8 7/8	9 1/4
Fisher Governor Co.	16 1/2	17
Foxboro Company (new)	41	43
Hagan Chemicals & Controls	42	43
Industro Transistor	9	9 3/4
Liquidometer Corp.	15 /4	16 1/8
W. L. Maxson	9 3/4	10 1/4
Penn Controls	22 1/8	22 7/8
Speer Carbon, Inc.	21 3/8	22
Sprague Electric	69 1/4	70 3/4
Taylor Instruments	73	75
Telechrome Mfg. Corp.	9 5/8	10 1/8
Telecomputing Corp.	9	9 1/4
Vitro Corp. of America	13 5/8	14 1/8

What are *your* Instrument Air Costs?



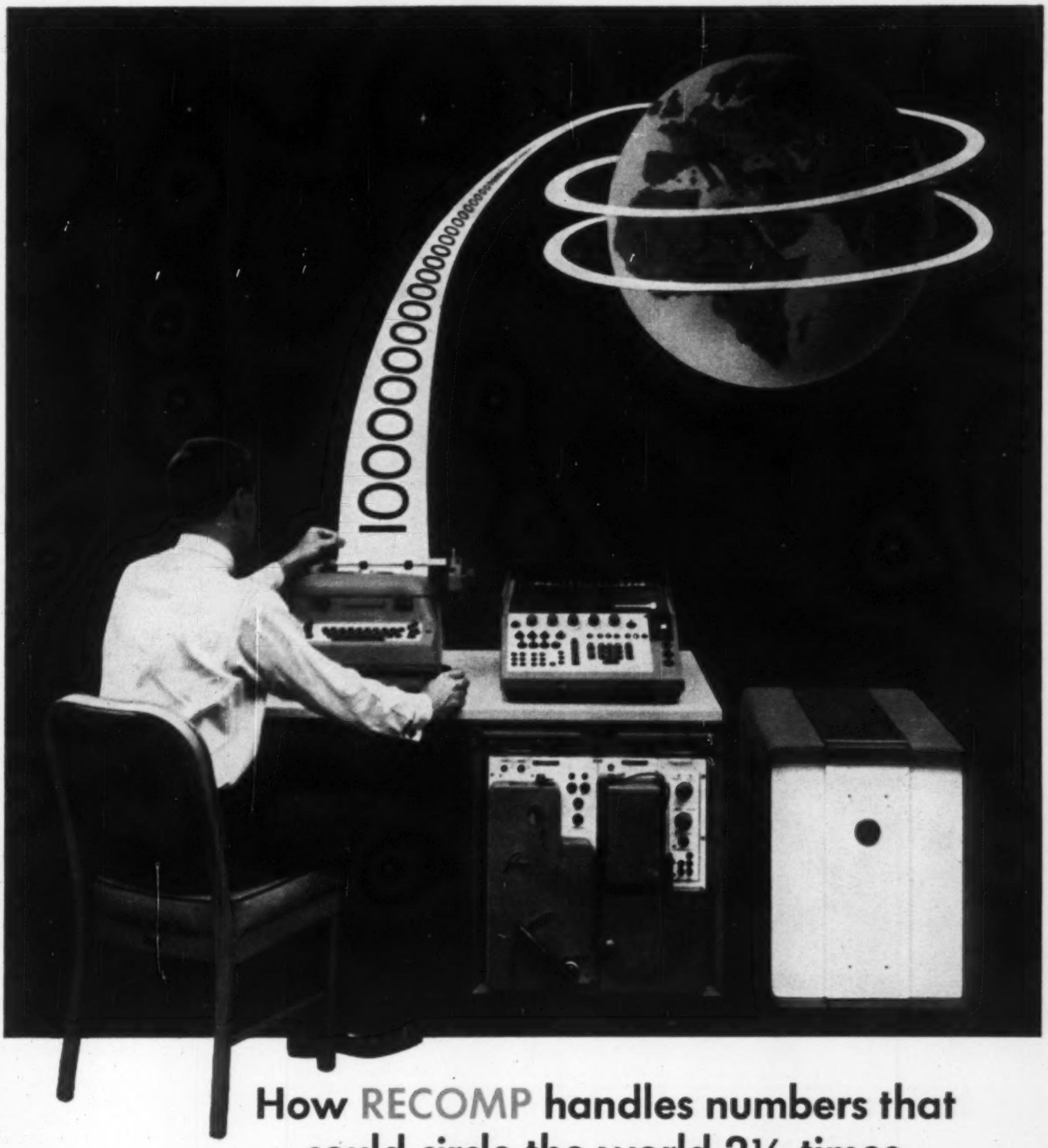
Are you removing moisture and oil most economically from your compressed air . . . are your instrument maintenance costs excessive . . . do you find dirt, sludge in your instrument air lines . . . are you overloading your chemical air drier?

Clean, dry air will eliminate instrument difficulties and production down time. Over 90% of the moisture contained in the average compressor discharge can be eliminated with the use of an Adams Aftercooler and Cyclone Separator providing 2° F. cooling — that is cooling the compressed air discharge to within 2° of the cooling water temperature. The moisture and oil vapors thus condensed are efficiently removed by the Cyclone Separator over the entire operating range. In many cases this air is entirely satisfactory for motor-air or other control applications. Where bone dry air is indicated requiring further chemical drier treatment, its load can be minimized to a polishing action. Thus, the bulk of the water is removed by lower cost condensation.

Why not investigate the many advantages of the Adams Aftercooler - Separator combination. Write today for Bulletin 714.

R. P. ADAMS CO., INC.
265 East Park Drive, Buffalo 17, New York

CIRCLE 23 ON READER-SERVICE CARD



How RECOMP handles numbers that could circle the world 2½ times

RECOMP can handle a floating point number greater than four billion factorial . . . or larger than the figure 1 followed by 41 billion zeros. Typewritten, the number would stretch around the world two-and-one-half times.

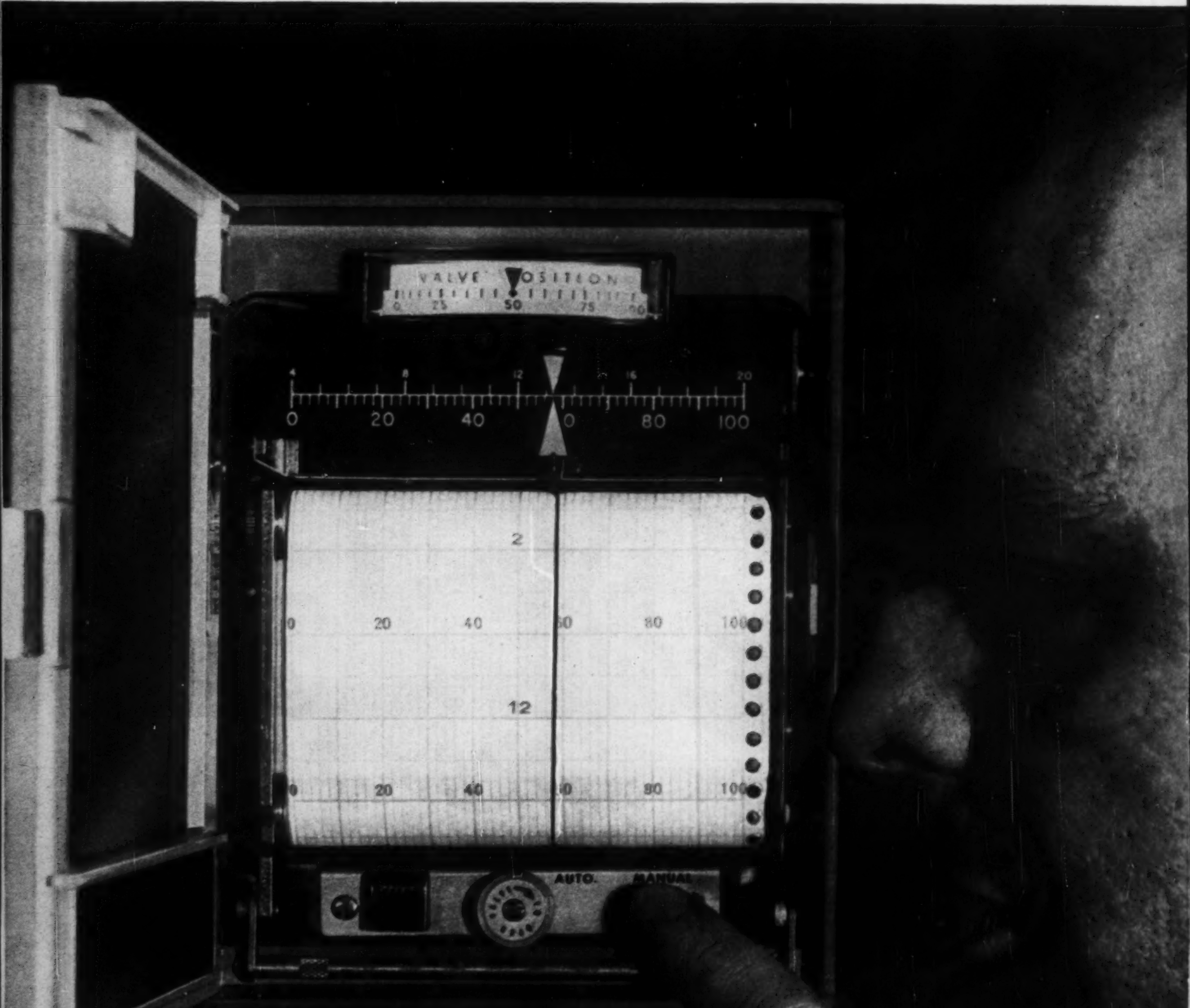
RECOMP is a low-cost, general purpose, digital computer—the original solid state computer with *proven reliability*. Its built-in floating point arithmetic and square root instructions come as a standard feature among RECOMP's 49 commands . . . at no extra cost.

Easy to operate, easy to program . . . RECOMP has a storage capacity of over 8000 instructions, simplified coding, fingertip control console with digital readout panel, and a high-speed photoelectric tape reader.

High-powered RECOMP is designed to solve problems of engineering, science, and industry. For information on how RECOMP can solve your special problems, write Autonetics Industrial Products Division, Dept. 607, 3584 Wilshire Boulevard, Los Angeles 5, California.

Autonetics
INDUSTRIAL PRODUCTS
A DIVISION OF NORTH AMERICAN AVIATION, INC. Other offices: Chicago, New York, Washington, D.C.

New *ElectriK Tel-O-Set*... needs in a single compact


VALVE POSITION
0 25 50 75 100
4 8 12 16 20
0 20 40 60 80 100
AUTO.
MANUAL

CIRCLE 24 ON READER-SERVICE CARD

everything an operator control station

This Honeywell electric control station meets all of your requirements for operator convenience.

One compact case houses *every* function the operator needs to supervise a control loop: indication of process variable and set point on the same scale; the controls needed to switch from automatic to manual; controls for manual control; and indication of valve position.

The *ElectriK Tel-O-Set* control station assures easier bumpless transfer than ever before available because there's no need to "line up" or "match" pointers. A null balance indicator eliminates guesswork, and the transfer doesn't have to be hurried since the valve remains under control during the transfer.

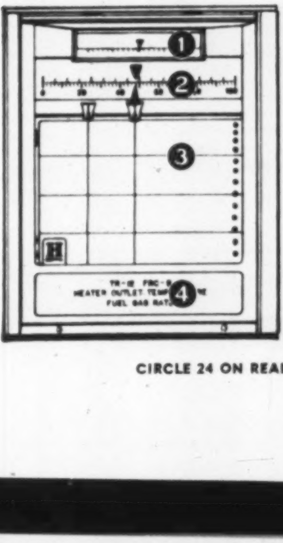
You can also order the controller with the proportional band, rate, and reset adjustments on the front of the panel conveniently located below the control station, or at the rear of the panel.

These are just a few of the features that make the new *ElectriK Tel-O-Set* control system an outstanding value. Your Honeywell engineer can give you complete details. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL,
Fall River, Massachusetts.

75th YEAR
PIONEERING THE FUTURE

Honeywell
First in Control
SINCE 1885



① Valve position indicator continuously indicates controller output when on automatic control.

② Set point index is conveniently located on same scale as process-variable pointer; you can see from a distance any deviation of variable from set point.

③ Rectilinear 4-inch calibrated chart is easy to read. At standard chart speed, four hours of recording is always visible. Unit has daily chart tear off or 30-day rewind. Both recorder and control station take the same 5½" x 6" panel cutout.

④ You get bumpless switching from automatic to manual control because you don't have to match pointers. In the balance position, the valve position indicator is part of a null circuit that compares controller output and manual output. When indicator reads 50%, both outputs are perfectly matched.

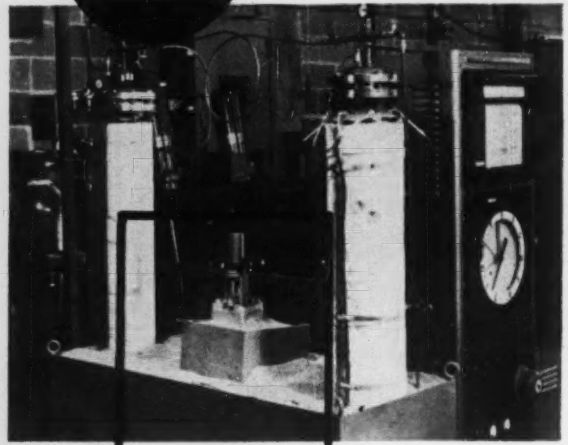
CIRCLE 24 ON READER-SERVICE CARD

P-K Paul Venturi-Ball Valve Specified By

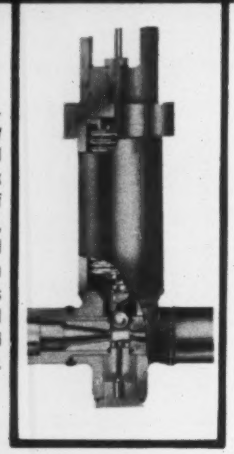
CASE HISTORY

ARGONNE NATIONAL LABORATORY

ARGONNE NATIONAL LABORATORY



P-K Paul Liquid Metal Valve in test loop under maximum temperature and pressure conditions at Argonne National Laboratory test site.



4" 1500 lb. Manually Operated Barstock Valve of 316SS, Stellited trim, with Bellows Seal and Extended Bonnet.

FOR 1600°F LIQUID SODIUM SERVICE

A year and a half ago Argonne National Laboratory selected a stock P-K Paul Liquid Metal Valve for testing and evaluation. Experience gained in testing this valve led to the purchase of five additional valves of this type for use in the TREAT "In-Pile Sodium Loop". Their use for this difficult service — tight shut-off of liquid sodium at operating temperatures above 1000°F — **illustrates again the superior performance of the unique Venturi-ball design.**

The P-K Paul Valve offers high flow capacity, wide rangeability, straight through non-turbulent flow, low operating thrust, self-purging characteristics, high resistance to erosion, abrasion and corrosion, and, most important in this application, positive shut-off.

For specification and application information on the complete line of P-K Paul Valves, write today for General Catalogue GV101.

General Kinetics Corporation

197 South Van Brunt Street · Englewood, New Jersey

CIRCLE 25 ON READER-SERVICE CARD

ICS EVENTS

July 28-29

7th Annual Symposium on Computers and Data Processing, Stanley Hotel, Estes Park, Colorado. For information write W. H. Eichelberger, Denver Research Institute, University of Denver, Denver 10, Colo.

July 11-August 22

Summer Program on Strain Gages, Control of Chemical Processes, Infrared Spectroscopy, Noise Reduction, etc., on campus of Massachusetts Institute of Technology. For information write J. I. Mattill, Associate Director, M.I.T. Summer Program, Cambridge 39, Mass.

July 28-29

Denver Research Institute's 7th Annual Symposium on Computers and Data Processing, Stanley Hotel, Estes Park, Colorado. For information write W. H. Eichelberger, University of Denver, Denver 10, Colorado.

August 1-3

4th Global Communications Symposium, Statler Hilton Hotel, Washington, D.C. For information write Ralph L. Clark, Office of Director of Defense Research and Engineering, Washington 25, D.C.

August 1-5

Gordon Research Conferences on Instrumentation, Colby Junior College, New London, New Hampshire. For information write Dr. W. George Parks, Gordon Research Conferences, Dept. of Chemistry, University of Rhode Island, Kingston, Rhode Island.

August 1-12

Summer Program on Modulation Theory and Systems, on campus of Massachusetts Institute of Technology. For information write Elie J. Baghdady, Dept. of Electrical Engineering, MIT, Cambridge, Mass.

August 3-6

Infrared Spectroscopy Institute Gas Chromatography Session, on campus of Fisk University. For information write Infrared Institute, Fisk University, Nashville, Tenn.

August 23-26

1960 Western Electronic Show & Convention, Los Angeles Memorial Sports Arena, Exposition Park, Los Angeles, Calif. For information write Ted Shields, 2411 W. 8th St., Los Angeles 57, Calif.

August 24-25

1960 Cryogenic Engineering Conference, on campus of University of Colorado. For information write K. D. Timmerhaus, Dept. of Chemical Engineering, Boulder, Colorado.

August 29-September 2

New York University Course in Automatic Electronic Test Equipment, on campus. For information write Mr. Feinsot, Special Services, New York University, 6 Washington Sq. N., N. Y. 3, N. Y.

August 29-31

Appalachian Gas Measurement Short Course, on campus of University of West Virginia. For information write R. E. Hanna, School of Mines, University of West Virginia, Morgantown, West Va.

September 6-8

Joint Automatic Control Conference, on campus of Massachusetts Institute of Technology. For information write Harvey A. Miller, JACC Program Committee IRE, Taylor Instrument Companies, 95 Ames St., Rochester 1, N. Y.

September 7-8

Second EIA Conference on Value Engineering, Disneyland Hotel, Anaheim, California. For information write J. A. Caffiaux, Electronic Industries Association, 650 Solmon Tower, 11 W. 42nd St., New York 36, N. Y.

September 7-9

1960 Joint Automatic Computer Conference, on campus of Massachusetts Institute of Technology. For information write JACC Chairman William D. Archibald, Energy Control Co., 5 Beekman St., New York 38, N. Y.

September 11-15

Third International Congress on Cybernetics, Namur, Belgium. For information write J. Lemaire, Secretariat, Association Internationale De Cybernetique, 13, Rue Basse Marcelle, Namur, Belgium.

September 11-17

American Society for Quality Control and I.R.E., Reliability Training Conference, Ft. Worth, Texas. For information write Henry Schifflett, Texas Instruments, Box 3-12, Dallas, Texas.

September 13-15

Fifth International Instruments & Measurements Conference, Stockholm, Sweden. For information write Helge Von Koch, Secretary-General, Stockholm 70, Sweden.

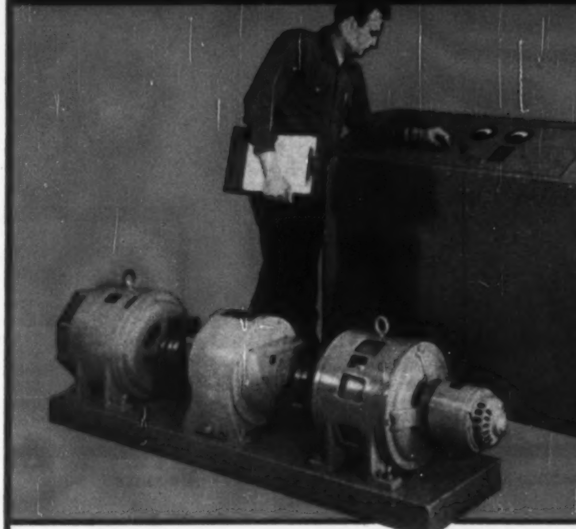
September 19-21

International Symposium on Data Transmission, Technische Hogeschool, Delft, Netherlands. For information write H. P. Williams, I.R.E., 1 East 79th St., New York 21, N. Y.

October 27-28

1960 Electron Devices Meeting, Shoreham Hotel, Washington, D. C. For information write H. W. Welch, Jr., I.R.E., 1 East 79th St., New York 21, N. Y.

SAVE 50% to 90%
ON
DC POWER SYSTEMS



The modern way to boost electronic power-system reliability is also the best way to cut cost, size, heat-loss, and complexity...by interposing a precisely-regulated motor-alternator set as a buffer-regulator between your DC power supplies and the power line. Typical Savings: 50-90%.

This technique often eliminates the need for regulated supplies...simple brute-force rectifiers suffice. If regulation **is** still necessary, the stress on the regulator is greatly reduced, hence remarkable savings in cost, etc.

Everybody's doing it...in Computers, Automation, Telemetry, Ground Support. Incidentally, **ignore** old-fashioned prejudices about rotary equipment...this is "turn-it-on-and-forget-it" gear...we even build them **brushless,** if you object to routine once-a-year maintenance.

Skeptical? Write today for this complete, authoritative, 32-page illustrated technical manual describing ESCO-RI PRECISE POWER SYSTEMS.

ESCO
ELECTRIC
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Partners
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RI
REGULATORS, INC.

CIRCLE 26 ON READER-SERVICE CARD

SAVE SPACE, WEIGHT AND MAINTENANCE with Versatile Compact MIL Spec Modules

For your electronic/electromechanical packaging problems, consult Oster specialists. Compact, transistorized, MIL spec, hermetically sealed, plug-in modules are available for numerous applications.

Typical building block basic units are illustrated. Temperature range is —55°C to +105°C. Basic units can be modified easily or completely redesigned to your specific requirement.

Oster engineers are specialists in creating densely packaged black boxes. These boxes can help you design more compactness and less weight into your systems. Phone or write your nearest John Oster office today.

GENERAL ENVIRONMENTAL CONDITIONS

A. Temperature—	—55°C to +75°C
B. Altitude—	—1000 Feet to +80,000 feet
C. Humidity—	Section 4.4.3 of MIL-E-5272
D. Vibration—	0.30 inch double excursion from 3 to 18 cycles per second and ± 2 g. acceleration from 18 to 500 cycles. (Without vibration isolators)
E. Crash Safety—	Repeated shocks of 30 g. with durations of 11 milliseconds
F. Salt Atmosphere—	Section 4.6.1 of MIL-E-5272
G. Fungus Growth—	Section 4.8.1 of MIL-E-5272
H. Sand and Dust—	Section 4.11.1 of MIL-E-5272

GENERAL PERFORMANCE SPECIFICATIONS

A. Gain Variation—	Less than 10% due to any given parameter extreme variation.
B. Linearity—	Better than 10% through the range of 3% to 80% of full output.
C. Noise—	Less than 5% of maximum output.
D. Phase Shift—	Less than 8 degrees.

Oster®

TYPE 9805-20—SYNCHRONIZER

Same as 9805-19 except Control Transformer Speed is 10 degrees/second—Min.

TYPE 9805-19—SYNCHRONIZER

Synchronizer

Motor Control Phase— 40/20 volts, 1.7 watts, 400 cycles
Motor Reference Phase— 57.5 volts, 2.2 watts, 400 cycles
Generator Excitation— 57.5 volts, 3.0 watts, 400 cycles
Generator Output— 0.3 volts/1000 R.N.M. Min.
Control Transformer Speed— 100 degrees/second-Min.
Control Transformer— John Oster Mfg. Co. 4053-19
Motor Generator— John Oster Mfg. Co. 6232-17

TYPE 9616-08—DEMODULATOR AMPLIFIER

Demodulator Amplifier

Input Impedance— Greater than 25,000 ohms
Output Impedance— 2830 ohms (Dual)
Voltage Gain— Greater than 115
Supply Voltage— 28.0 D.C.

TYPE 9616-07—SYNCHRONIZER AMPLIFIER

Synchronizer Amplifier

Input Impedance— Greater than 50,000 ohms
Voltage Gain— Greater than 250
Load— Control Phase of Motor Generator of 9805-19 or 9805-20

TYPE 9616-16—4-CHANNEL ISOLATION AMPLIFIER

4-Channel Isolation Amplifier

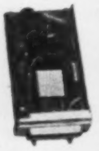
Input Impedance— 1200 ohms per channel
Voltage Gain— .98 ± .01 per channel
Load Impedance— 1200 ohms per channel
Supply Voltage— 48VDC

TYPE 9616-09—SERVO ACTUATOR AMPLIFIER

Servo Actuator Amplifier

Input Impedance— Greater than 50,000 ohms
Output Impedance— 400 ohms
Voltage Gain— Greater than 900
Supply Voltages— 100.0 volts D.C. 28.0 volts D.C.

TYPE 9616-15—RELAY AMPLIFIER


Relay Amplifier

Input Impedance— Greater than 15,000 ohms
Relay Closing Voltage— 150-175 Millivolts, 400 cycles
Relay Opening Voltage— 125-150 Millivolts, 400 cycles
Relay Contacts— 4 Pole, Double Throw—Dry Circuit
Supply Voltage— 28.0 V. D.C.

TYPE 9616-06—SUMMING AMPLIFIER (DUAL)

Summing Amplifier

Summing Inputs— 10 (per channel)
Gain— Nominal 1.0; variable from 0.1 to 10.0
Input Impedance— Dependent on Summing Channel. (50,000 ohms—500,000 ohms)
Load Impedance— Greater than 10,000 ohms
Supply Voltage— 28 V. D.C.

John Oster MANUFACTURING CO.

Specialists in Instrumentation and Display
Avionic Division
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OTHER PRODUCTS INCLUDE:

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Engineers For Advanced Projects: Interesting varied work on designing transistor circuits and servo mechanisms.

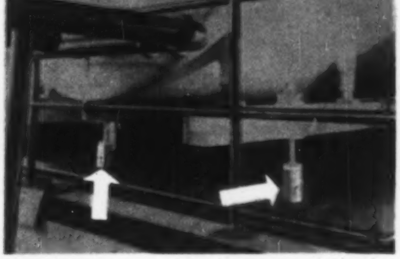
Contact Mr. Dallas Nielsen, Personnel Manager, in confidence.

CIRCLE 27 ON READER-SERVICE CARD

Quick check on bulk. Thompson's Dairy man checks weight of truckload of milk, just pumped into bulk tank, on the SR-4® indicator. Magnifying glass facilitates accurate reading of scale. Also available are automatic printers which furnish weight printed on tape.

"We were paying for more milk than we got"

—reports Thompson's Honor Dairy of Washington, D.C.



Space is no object. SR-4® load cells are compact . . . support the entire weight of the tank, but add only a few inches to its overall height.

"...now we get .05% consistent accuracy with our new Baldwin SR-4® system"

When this leading dairy converted to bulk milk pick-up, all shipments had to be accepted on a volumetric basis. Spot checks revealed errors in measurements as high as 3½%.

Then the company installed an SR-4® weighing system on one of its bulk tanks—four compact load cells (which come completely sealed against moisture) beneath the tank . . . and a precision indicator located at the receiving station, almost a block away. Now each shipment is measured quickly and easily, as received, and with a consistent accuracy of .05% or better.

SR-4® systems conform to the sealing requirements of the National Bureau of Standards. They are readily installed on existing facilities . . . are considerably less expensive than mechanical scales for multiple tank systems. No corrosion problems, wearing of parts, etc.

Are you losing money through inaccurate measurement? Find out how easily you can install a B-L-H SR-4® measuring system in your plant. Send for free booklet No. 4410. Write Dept. 7-G.

Advanced force measurement began here

BALDWIN · LIMA · HAMILTON

Electronics & Instrumentation Division • Waltham, Mass.

SR-4® Strain Gages • Transducers • Force Measurement Systems

CIRCLE 28 ON READER-SERVICE CARD

WIDER CHOICE

DEKORON®

NEW POLY-COR

Dekoron products are first in the field for wide selection . . . quality . . . service . . . new product development. And the New Poly-Cor is the latest development to make instrument tubing news.

For here is a superb instrument line harness of exceptional quality with features never before available. Check them carefully. New grade of all-black polyethylene for operation at higher temperatures . . . number coding of tubes for easier hook-up . . . Mylar® vapor barrier . . . lighter weight. All these features are now standard in New Poly-Cor — and at no increase in price.

Request a Dekoron sample today and get full specification data from your local representative. Dekoron products represent years of experience in the instrument field . . . are application-engineered by the company with the greatest application experience.

A-2318A

Lengths
UP TO 1000 FEET
Vinyl Sheath
FLEXIBILITY
Lighter Weight
EASIER INSTALLATION
Number Coding
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All-Black Tubes
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Mylar Barrier
NO PENETRATION
New Black Polyethylene
HIGHER TEMPERATURE OPERATION

Dekoron® products

quality • research • service

SAMUEL MOORE & COMPANY · DEKORON PRODUCTS DIVISION · **MANTUA, OHIO**

CIRCLE 29 ON READER-SERVICE CARD

Factory sales of electronics industry in 1959 were $9.2 billion, says Electronic Industries Association in 1960 Fact Book, as follows: military—$4.7 billion; consumer plus replacement—$2.9 billion; industrial and commercial—$1.6 billion.

Ultrasonic cleaning market is estimated at $15 million in 1960, compared to $11 million in 1958, and will reach above $50 million by 1965, says H. Osterman, sales manager of Branson Instruments.

The median annual salary reported to the National Register of Scientific and Technical Personnel by some 137,000 scientists employed full time during the years 1956-1958 was about $7,900. Those reporting specialties in chemical engineering and the medical sciences had the highest median salaries—over $10,000; lowest were those in the agricultural and biological sciences, meteorology, and psychology, with median salaries below $7,000. Almost half of the total number of respondents were in private industry or self-employed; 28% were employed by educational institutions; 14% were Federal Government civilian employees. 64% of the employed scientists held advanced degrees. Nearly half of those reporting were engaged in research and development activities; teaching was reported by 16%. Those in management or administration activities had the highest median salary ($11,000); teaching, the lowest ($6,500).

Funds for R&D in US are reported by NSF as follows:

TABLE 1.—FUNDS FOR PERFORMANCE OF RESEARCH AND DEVELOPMENT IN THE U.S., BY SECTOR,[1] 1953–59 [2]

[Millions of dollars]

Sector	1953–54	1954–55	1955–56	1956–57	1957–58	1958–59 (Projected estimate)	1959–60 (Projected estimate)	Percent increase, 1953–54 to 1959–60
Total	$5, 150	$5, 620	$6, 390	$8, 460	$10, 050	$11, 160	$12, 430	141
Federal Government agencies	970	950	1, 090	1, 280	1, 450	1, 720	1, 780	83
Industry [3]	3, 630	4, 070	4, 640	6, 440	7, 730	8, 400	9, 400	159
Colleges and universities [3]	450	480	530	600	720	840	1, 000	126
Other nonprofit institutions [3]	100	120	130	140	150	200	250	140

TABLE 2.—SOURCES OF FUNDS FOR RESEARCH AND DEVELOPMENT IN THE U.S., BY SECTOR[1] 1953–54, 1956–57, and 1957–58[2]

[Millions of dollars]

Sector	1953–54	1956–57	1957–58	Percent increase, 1953–54 to 1957–58
Total	$5, 150	$8, 460	$10, 050	95
Federal Government agencies	2, 740	4, 960	6, 130	124
Industry	2, 240	3, 260	3, 660	63
Colleges and universities [3]	130	170	180	47
Other nonprofit institutions [4]	40	70	80	73

[1] For a description of each sector, see *Technical Notes.*

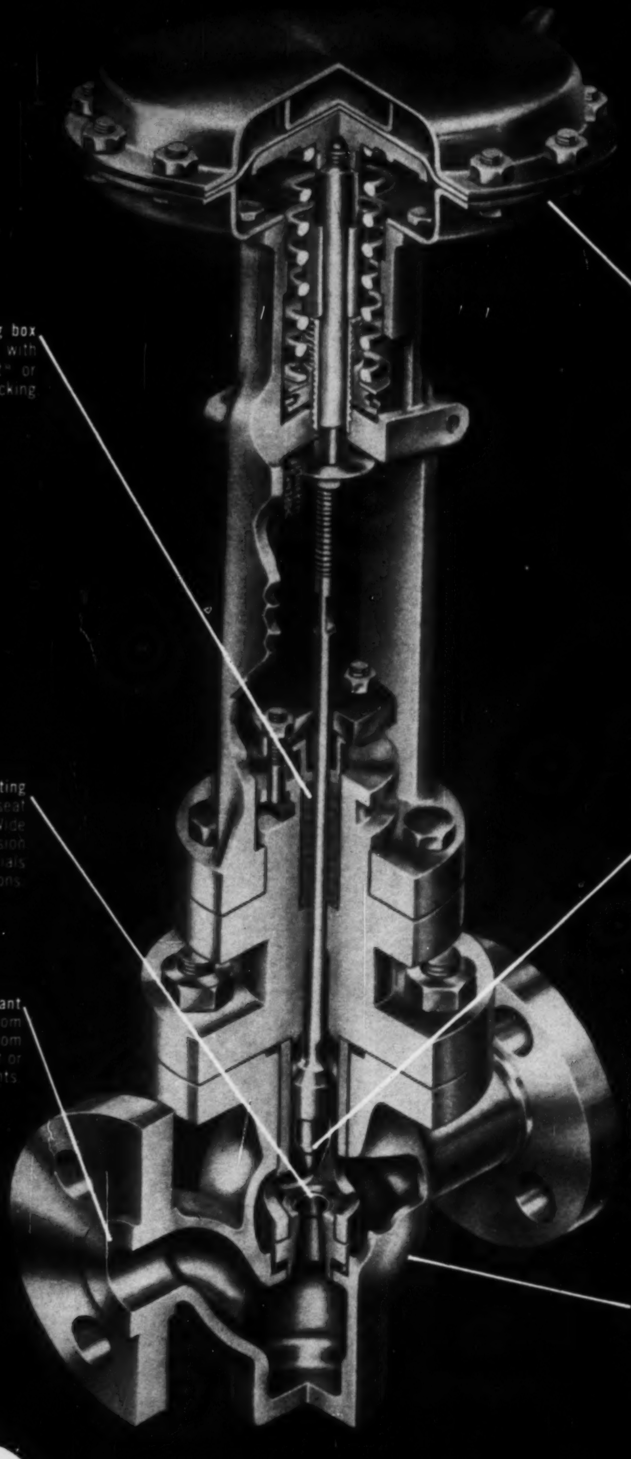
[2] The data for 1953–54, published previously, are revised; for the remaining years, the data are preliminary. Detail on sources by sector is not available for 1954–55, 1955–56, 1958–59, and 1959–60, but national totals for these years have been estimated at $5,620, $6,390, $11,160, and $12,430 millons, respectively, on the basis of data on performance. (See table 1.)

[3] Includes all state and local funds received by public institutions of higher education, which were used for research and development.

[4] Includes state and local funds, received by such nonprofit institutions as museums, zoological gardens, and academies of science, which were used for research and development.

NOTE: Percentages based on unrounded figures.

Source: National Science Foundation, December 1959.



Flanged, thru-bolted stuffing box —no lubricator needed with Leslie-Lubrisoft® or Teflon V-Ring packing

Actuators for normally open or normally closed valves with 35, 55, 85 and 135 square inch effective areas

Long-Life, Stellite seating surface on renewable seat insert for steam service. Wide selection of alternate corrosion and erosion resistant materials for other applications.

Interchangeable inner valve shapes and materials — choice of needle plugs, V-port, quick opening, micro tapers

Corrosion-erosion resistant materials in ASA rating from 150 to 2500 lbs. Select from a wide line to meet present or future system requirements.

High Capacity Body — any end connections in ½ to 3" sizes

TRADE LESLIE MARK

REGULATORS and CONTROLLERS

NOW—

CHANGE VALVE TRIM IN 15 MINUTES

New Leslie Cage Trim Control Valve is Designed for Today's Use and Tomorrow's Changes.

Here's a control valve designed in steel and alloy steels that offers new assurance the valve you initially specify and install *will always fit an application*—even if changes in plans or future system changes might ordinarily call for complete valve replacement.

The new Leslie cage trim valve allows complete trim inspection in 15 minutes without removing the valve from the line. You can also switch valve action or size of actuator. Or, change valve characteristic or trim materials at will with an inexpensive interchangeable trim kit that reduces spare valve and valve parts inventories. Cage trim cuts maintenance and system modification costs to the bone—it's the kind of valve that makes foresight almost as good as "hindsight".

For sizing and capacity data on cage trim control valves, write for Bulletin or contact your Leslie Engineer—he's listed under 'Valves' or 'Regulators' in the Yellow Pages.

LESLIE **Leslie Co., 704A Grant Ave., Lyndhurst, New Jersey**

A Unbalanced valves up to 2500 lb ASA ratings.

B Piston balanced valves up to 600 lb ASA ratings.

C Double seated control valves to 600 lb ASA ratings.

D High pressure-high temperature control valves.

E Angle body control valves.

A

B

C

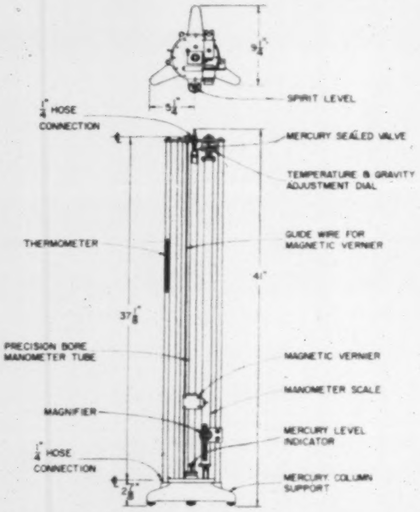
D

E

CIRCLE 30 ON READER-SERVICE CARD

ICS BRIEFS

Manometer Standard



The W&T Calibrating Standard . . . is a mercury column arranged for bench mounting and may be used for measuring either absolute or differential pressure.

Features include magnetic vernier, visible zero setting, leveling base, built-in thermometer, temperature and gravity compensated scale, integral bubble level, full-range indication, precision bore tube, mercury sealed valve, filtered pressure inlet, fixed well, bench mounting, choice of graduations, meniscus reading eliminated, use for absolute or differential pressure or as a barometer . . . (*From new 4-page Bulletin TP-32-A-4, Wallace & Tiernan Inc.*, 25 *Main St., Belleville* 9, *N. J.*)

FOR THIS LITERATURE CIRCLE 153 ON READER-SERVICE CARD

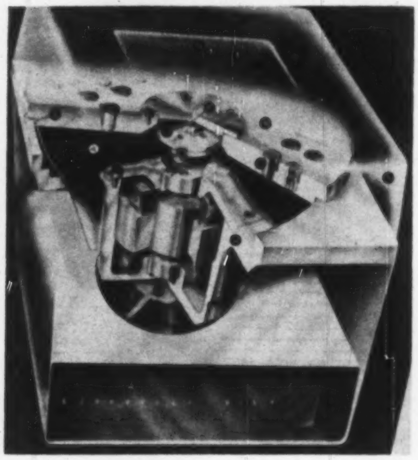
Continuous Supervisory Control

The Varelectric 880 Series provides field economy and operating efficiency in a remote control system for supervising pump motors and valve operators, or any two- or three-status devices requiring momentary or sustained contacts.

The polarity of the DC current signal, transmitted by the control unit to the field unit, establishes the status demand for the controlled device. Thus, either of the two status conditions, plus "off", can be instantaneously demanded from the control unit. This arrangement provides a simple and most reliable means of remote control . . . (*From new 4-page Bulletin CP-*3708, *Vapor Recovery Systems Co.*, 2820 *No. Alameda St., Compton, Calif.*)

FOR THIS LITERATURE CIRCLE 154 ON READER-SERVICE CARD

Disk Memory

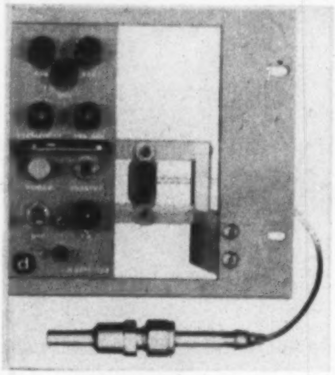


The device consists of a flexible Mylar disk (A) that is rotated close to a smooth backplate (B) in which read/write heads (C) are embedded flush with the smooth surface . . .

When the disk is at rest, it falls away from the backplate; but in motion, the limp disk becomes flattened by centrifugal force and disk pumps air through the orifice and out at the disk periphery. A small, controlled separation is maintained between the storage medium and the read/write heads by the motion of a gas . . . (*From 4-page Bulletin BD-*100, *LFE Applied Research Lab., a div. of Laboratory for Electronics, Inc.*, 1079 *Commonwealth Ave., Boston* 15, *Mass.*)

FOR THIS LITERATURE CIRCLE 155 ON READER-SERVICE CARD

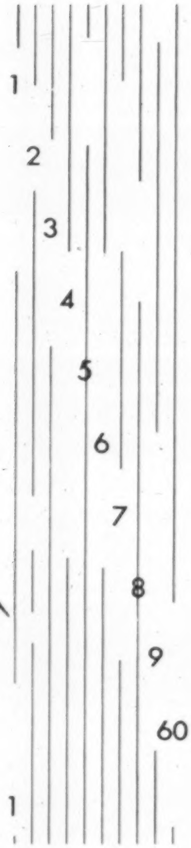
Liquid Gas Detector



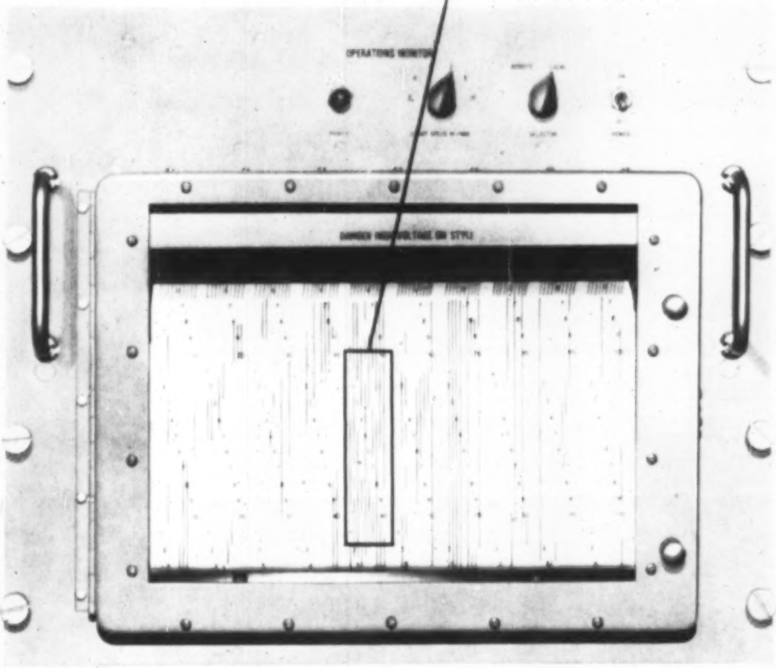
The L-G Detector senses the state of the cryogenic substance with a transducer whose active part is an extremely fine, electrically heated wire. When the transducer is surrounded by a liquid rather than by gas or vapor, the fine wire loses heat more readily, and its temperature and electrical resistance are lower. It is this difference in resistance that is used in detection . . . A response time of less than 100 ms may be attained . . . (*From new 4-page folder "L-G Detector," Convair Instruments*, 3595 *Frontier St., San Diego* 10, *Calif.*)

FOR THIS LITERATURE CIRCLE 156 ON READER-SERVICE CARD

CIRCLE 31 ON READER-SERVICE CARD⟶

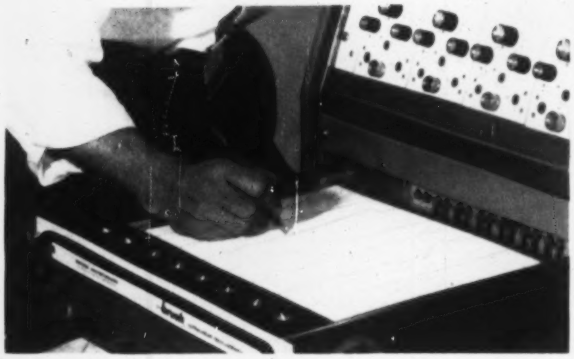


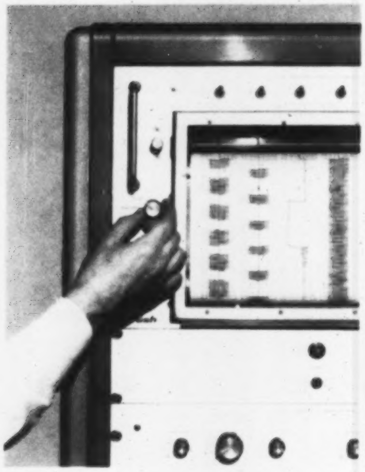
insight at 4 milliseconds

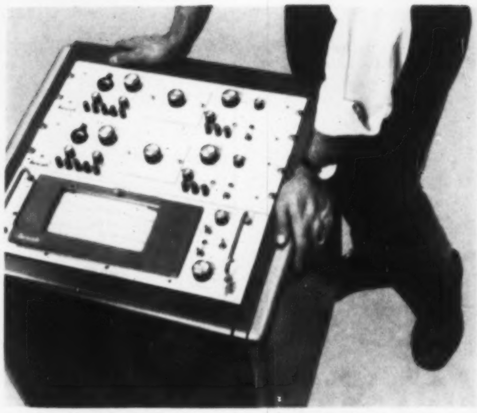


recorded with Brush operations monitors. Multiple high-speed events are reported in writing within 4 milliseconds of occurrence—to establish the basis for split-second, million dollar decisions necessary in today's complex control systems. Up to 120 separate "on-off" event signals are monitored and permanently recorded on a chart only 12″ wide. Fixed-stylus electric writing provides sharp, reproducible traces of uniform clarity. Chart speeds from one to 250 mm/sec permit a precise interpretation of all events, with resolution up to 500 signal changes per second. For military or industrial analysis and control, no direct writing recording system can match the capabilities of Brush Operations Monitors. Write today for complete specifications and application data.

brush INSTRUMENTS
DIVISION OF
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO







in direct

writing

systems

only Brush eliminates compromise

Avoid a "second best" choice. Get exactly what you need. Only Brush permits selection of . . . **Writing Method** . . . ink, electric or thermal . . . **Trace Presentation** . . . curvilinear or rectilinear . . . **Configuration** . . . vertical or horizontal, rack mounted or portable models. Also . . . chart speeds from 50″/sec to 10″/day . . . functionally designed control panels . . . readily accessible components for fast inspection, simple adjustment . . . complete, easy to understand operating manuals. Get the industry's most advanced design concepts. You never need compromise when you specify Brush. Complete information at your request.

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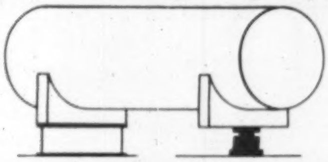
Hydraulic Weighing Systems



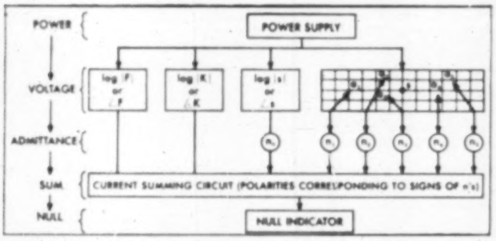
The basic components of the Emery Hydraulic Weighing Systems are: The Emery Cell; a Tank Pivot Assembly; a stay strut assembly; and the necessary instrumentation such as an Indicator, Recorder or Controller.

In effect, every Emery Weighing System is a transducer . . . Fundamentally, the Emery Cell is a specially-designed rigid cylinder and piston mechanism with the piston held centrally in the cylinder by a flat, annular stay-plate and a flat bridge ring . . .

This arrangement is a simplified adaptation of any Emery Weighing System to a horizontal tank. The back part of the tank is supported on an "I" beam or two Emery ball pivot assemblies. The front part of the tank is supported on one type EC Emery Cell . . . The hydraulic pressure in the cell actuates an indicator, recorder or controller which is so calibrated that it reads directly the weight of the contents of the tank . . . (*From new 12-page Bulletin* 581, *A. H. Emery Co., New Canaan, Conn.*)

FOR THIS LITERATURE CIRCLE 156 ON READER-SERVICE CARD

Computer for Algebraic Functions of a Complex Variable



In practical engineering problems, it is usually necessary to determine the values of |F| (magnitude of F) and ∠F (phase angle of F) corresponding to each of a large number of values of s. Sometimes the values are used directly as in plots of gain and phase shift as a function of frequency. In other cases, a large number of trial values of s must be substituted in the equation to find the values of s which satisfy the equation when the value of F is specified . . . The numerical and graphical methods for solving such problems are at best rather tedious . . . The unique advantage of the *esiac* Computer Model 10 is that a change in s involves only the settings of the magnitude and phase of s. The values of the a's and other parameters are set only once at the start of a given problem and require no further attention as the values of |F| and F are determined at various values of s . . . (*From new 4-page Catalog Sheet C-20, Electro-Measurements, Inc., 7524 S. W. Macadam, Portland 1, Ore.*)

FOR THIS LITERATURE CIRCLE 157 ON READER-SERVICE CARD

← **CIRCLE 32 ON READER-SERVICE CARD**

New 3-Way Nylon-Body Solenoid Valve... List Priced as Low as $10.75...

(Quantity Discounts Available)

Outlasts, Outperforms Steel!

Valcor's new 3-way Nylon solenoid valve, SV-54 Series, outlasts and outperforms steel, yet is list priced as low as $10.75! In general purpose and O.E.M. installations, where millions of operating cycles are essential, this new Valcor valve not only works best but costs less.

Its nylon seat outlasts steel . . . its port threads outlast steel . . . pound for pound it's **3 times stronger than steel.** Dry seal threads, no compound is needed—and they won't loosen even under severe vibration. Nylon is non-corrosive so you have no atmospheric problems. And the hard stainless plunger is a workhorse for millions of cycles. Bubble tight sealing. Available in normally open, normally closed and "directional control" configurations in all normal AC and DC voltages . . . 1½" square x 3" long (valve illustrated).

Write today for complete technical data on this shock-resistant, pressure-proof valve—the 3-way nylon-body valve, SV-54 Series, that's 3 times stronger than steel, yet costs less. Try it on your toughest application.

VALCOR SOLENOID VALVES

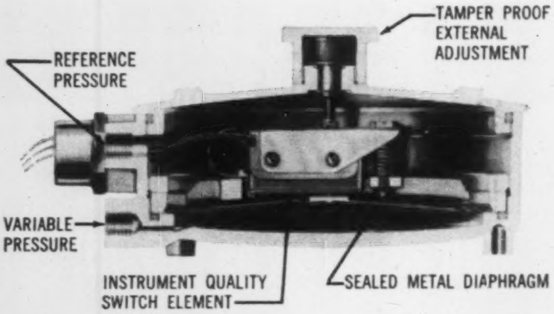
VALCOR ENGINEERING CORP.

5366 Carnegie Avenue, Kenilworth, New Jersey

CIRCLE 33 ON READER-SERVICE CARD

VALCOR
SOLENOID VALVES

SV-54 Series


TAMPER PROOF EXTERNAL ADJUSTMENT
REFERENCE PRESSURE
VARIABLE PRESSURE
INSTRUMENT QUALITY SWITCH ELEMENT
SEALED METAL DIAPHRAGM

INSTRUMENT QUALITY DIFFERENTIAL SWITCH

senses pressure differences from .45 to 45 inches of water

Used in hopper level indicating, on oil burner blower safety control, in instrumentation or similar applications where it is necessary to sense a pressure difference of .45 to 45 inches of water between a variable and a reference pressure. The reference pressure may be as high as 30 P.S.I.

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY and DEPENDABILITY maintained during operating life due to direct acting design	LINKAGES & BEARINGS which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements	LIQUID SWITCHING ELEMENTS which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	ACCORDION BELLOWS which make the pressure switch sensitive to vibration.

ASK FOR NEW CATALOG 9-PS FREE

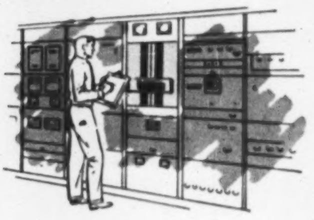
PRESSURE SWITCH DIVISION

barksdale valves

5125 Alcoa Avenue, Los Angeles 58, California

CIRCLE 34 ON READER-SERVICE CARD

General-purpose, Microsecond Computer

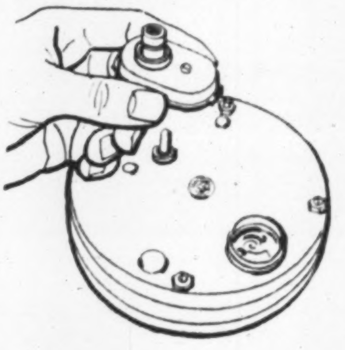


The PB 250 is a general purpose digital computer that may be applied to an extremely broad range of scientific, industrial, and military problems. The PB 250 combines a large, expandable memory and a versatile command structure with a computing speed in the microsecond range.

A few outstanding features of the PB 250 are: 12 microsecond addition speed . . . , 1808-word expandable memory . . . , 46-instruction command structure . . . , simple programming . . . , flexible input-output system . . . , exceptional reliability . . . , systems integration . . . only $30,000. The design of the PB 250 enables it to be mounted as a systems component in 31½ in. of a standard relay rack . . . (*From New 4-page brochure, Packard Bell Computer, a subsidiary of Packard Bell Electronics,* 1905 *Armacost Ave., Los Angeles* 25, *Calif.*)

FOR THIS LITERATURE CIRCLE 158 ON READER-SERVICE CARD

Gas-powered Chart Drive

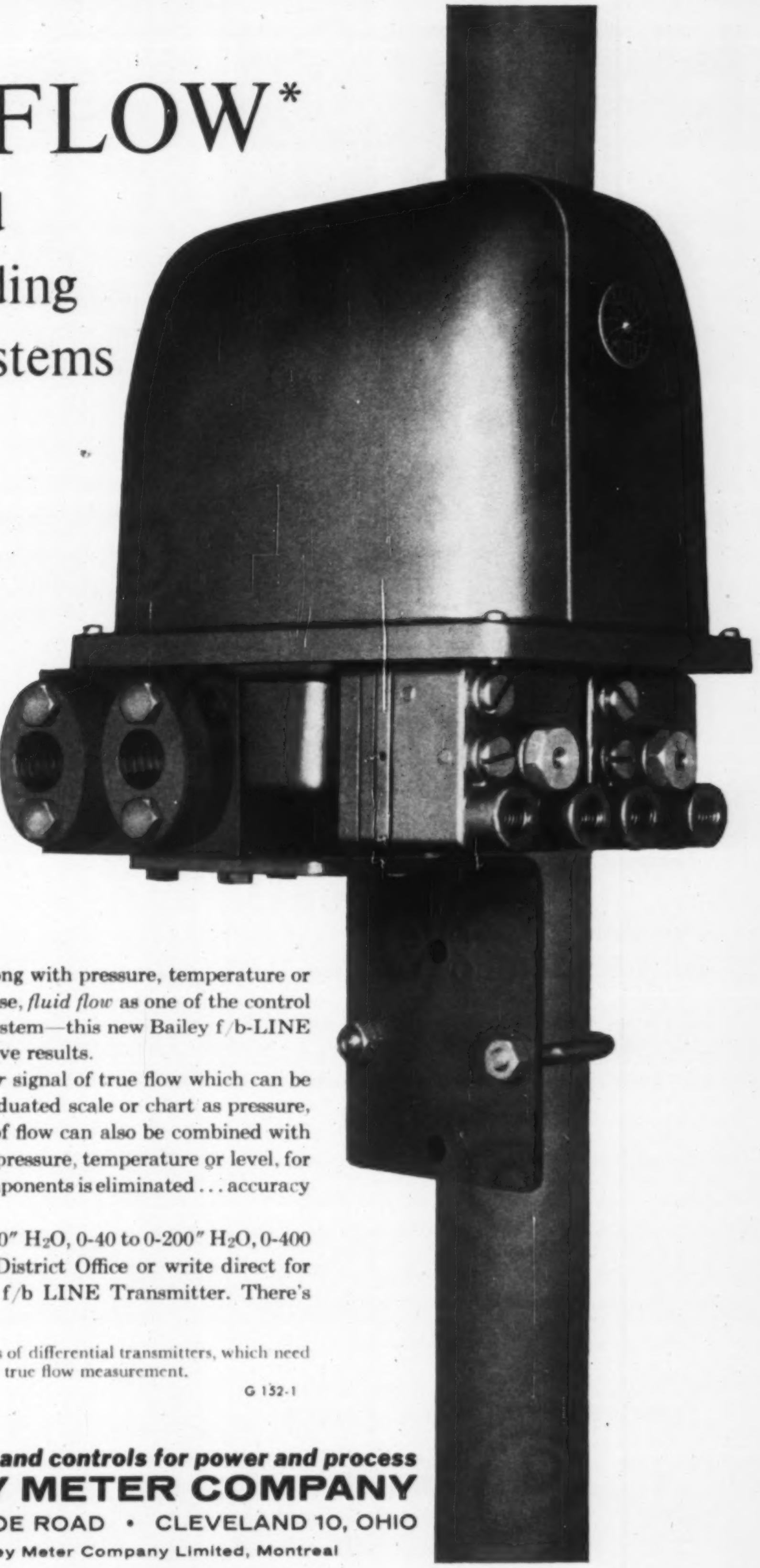


Basically the Gas Drive is the same drive as Rockwell standard spring-driven units, but uses gas or air via a piston as the constant source of power. The piston, "firing" every 45 seconds, loads the drive spring. This action requires only one cubic centimeter of gas and thus uses less than 6 cubic feet of gas per day to operate. This small consumption presents no exhaust problem and will not burn a flame at the exhaust outlet . . .

The stainless steel piston assembly completely entrains the gas as it passes through the drive so that the timing mechanism is not exposed to any corrosive gases . . . (*From new 4-page Bulletin* 1107, *Rockwell Mfg. Co.,* 400 *N. Lexington Ave., Pittsburgh* 8, *Pa.*)

FOR THIS LITERATURE CIRCLE 159 ON READER-SERVICE CARD

Measures
TRUE FLOW*
to simplify and improve recording and control systems



If you intend to record *fluid flow* along with pressure, temperature or level—or if you now use, or plan to use, *fluid flow* as one of the control factors in a multi-element control system—this new Bailey f/b-LINE Transmitter can simplify and improve results.

It measures and transmits a *linear* signal of true flow which can be recorded on the same uniformly graduated scale or chart as pressure, temperature and level. This signal of flow can also be combined with other linear signals such as those of pressure, temperature or level, for improved control. Need for extra components is eliminated . . . accuracy of flow reading is increased.

Wide selection of ranges: 0-4 to 0-20″ H_2O, 0-40 to 0-200″ H_2O, 0-400 to 0-2000″ H_2O. Call your Bailey District Office or write direct for complete data on the new Bailey f/b LINE Transmitter. There's nothing like it.

*As opposed to pressure-drop measurements of differential transmitters, which need external square root extractors to produce true flow measurement.

G 152-1

BAILEY METERS

Instruments and controls for power and process

BAILEY METER COMPANY

1041 IVANHOE ROAD • CLEVELAND 10, OHIO

In Canada—Bailey Meter Company Limited, Montreal

CIRCLE 35 ON READER-SERVICE CARD

HIGH
BRIGHTNESS
NEON
Actual Size
No. 132-408H-991
No. 135-408H-331
NE-51H
8
TIMES
BRIGHTER

DIALCO PILOT LIGHTS

with Built-in Resistor

(a patented DIALCO feature)

for the **Neon Glow Lamp NE-51H** (High Brightness)

RUGGED: The NE-51H Neon Glow Lamp is made to resist vibration and is proof against sudden failure. It may be operated at about 3 times the level of current applied to the standard neon lamp, and it will produce 8 times as much light—*with long life!* Requires low power—less than 1 watt on 250 V circuit. Recommended for AC service (may be used on DC circuits above 160 V).

BUILT-IN current-limiting resistor (U.S. Patent No. 2,421,321):
For use on 105-125 volt and 210-250 volt circuits.
In DIALCO Pilot Lights, the built-in resistor is completely insulated in moulded phenolic and sealed in metal.

COMPACT: Units are available for mounting in 9/16" and 11/16" clearance holes...in a wide choice of lens styles and colors, terminal types, metal finishes, etc.
Meet applicable MIL Spec and UL and CSA requirements.

Every assembly is available complete with lamp.

SAMPLES ON REQUEST—AT ONCE—NO CHARGE

Ask for Bulletin No. 100 and Catalogue L-161B.

Foremost Manufacturer of Pilot Lights
DIALIGHT
CORPORATION

42 STEWART AVE., BROOKLYN 37, N. Y. • HYacinth 7-7600

CIRCLE 36 ON READER-SERVICE CARD

ICS BRIEFS

True-Rms Digital Voltmeter

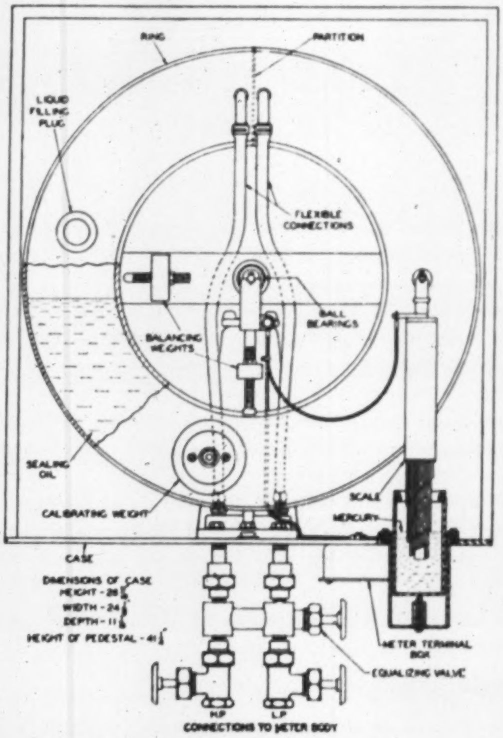
This revolutionary instrument incorporates a unique temperature stabilized diode network, operating on the square law principle, to yield a true rms voltage reading, regardless of the AC waveform or DC. No hot wire elements of any kind are used.

Specifications include: 0.1% accuracy for crest factors up to two; 0.1% response from 50 cps through 5KC and at DC; calibration accuracy held for minimum of 30 days—typically much longer; automatic ranging: 1 volt to 999.9 volts with manually selected 0.1 volt to 1 volt range . . . (*From new 2-page pamphlet, Electro Instruments, Inc.*, 3540 *Aero Court, San Diego* 11, *Calif.*)

FOR THIS LITERATURE CIRCLE 160 ON READER-SERVICE CARD

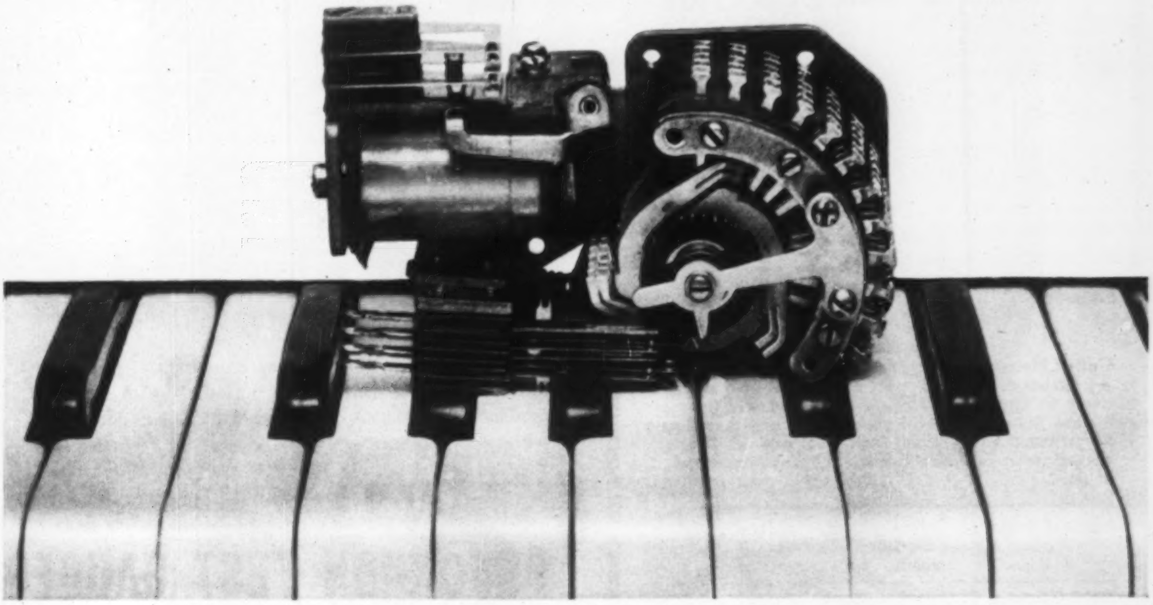
Ring-Balance Meter

The gas is confined to the ring-balance and does not come in contact with the electrical elements of the meter, therefore dirty or corrosive cases cannot affect its operation . . . The Republic ring-balance meter is essentially a tilting manometer . . . The hollow ring is partitioned at the top to form a U-tube . . . (*From new* 28-*page Bulletin* 59-5, *Republic Flow Meter Co., subs. of Rockwell Mfg. Co.*, 2240 *Diversey Parkway, Chicago* 47, *Ill.*)


RING
PARTITION
LIQUID FILLING PLUG
FLEXIBLE CONNECTIONS
BALL BEARINGS
BALANCING WEIGHTS
SEALING OIL
CALIBRATING WEIGHT
SCALE
MERCURY
CASE
DIMENSIONS OF CASE
HEIGHT - 28
WIDTH - 24
DEPTH - 11
HEIGHT OF PEDESTAL - 41
METER TERMINAL BOX
EQUALIZING VALVE
HP
LP
CONNECTIONS TO METER BODY

FOR THIS LITERATURE CIRCLE 161 ON READER-SERVICE CARD

AE



To the Engineer

looking for a small-scale switch to do a large-scale job

If you have to perform complex switching maneuvers, fast, and in small space, you'll go for AE's Type 44 Rotary Stepping Switch.

This mere handful of rugged switching accommodates up to six bank levels, with 10 points plus home—will do the work normally assigned to whole banks of relays.

The miniature Type 44, and its big brother, Type 45, are the only stepping switches with a positive-action, free-floating pawl. This unique design eliminates armature-stop and pawl-stop readjustment – prevents pawl wear-and-tear, breakage, and binding. The pawl locking teeth position the rotor automatically, making overthrow impossible.

Incidentally, AE engineers are artists at composing simple circuits to do complex things – and AE can supply assembled and prewired control packages to your specs. Either way, we can help you cut costs.

For answers to *your* automatic control problems, write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Circular 1698-H on Rotary Stepping Switches.

AE
CAN
DO

AUTOMATIC ELECTRIC

Subsidiary of

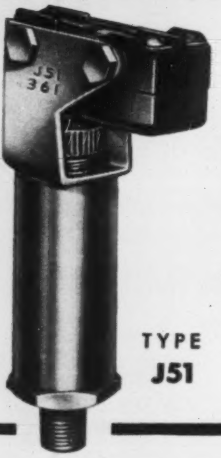
GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

CIRCLE 37 ON READER-SERVICE CARD

Wide Range
Space Saving

J51



PRESSURE VACUUM CONTROL

TYPE
J51

United Electric's Type J51 Pressure-Vacuum Control is a skeleton, precision-built unit that is used extensively in applications where space and weight are factors. It has an uncalibrated adjustment that may be provided with locking feature if desired. It is a rugged, wide range control suitable for a multitude of uses.

Adjustable Ranges ...	Models available in ranges of 50, 75, and 250 psi between 0 and 350 psi limits.
Switch Differential ...	Approximately 5 or 10 psi dependent on model.
Switch Ratings	Up to 15 amps. at 115 or 230 volts A.C. Also available are 20 amps. A.C., manual reset, D.C., and other switches.
Switch Types	Normally Open, Normally Closed, or Double Throw — no neutral position.
Maximum Pressure ...	350 psi.
Electrical Connections ..	Lead wires attached to screw type terminals on switch.
Pressure Connection ..	Via a ⅛" male NPT connection.
Mounting	Via pressure connection.
Bellows Material	Either type 321 or 347 stainless steel.

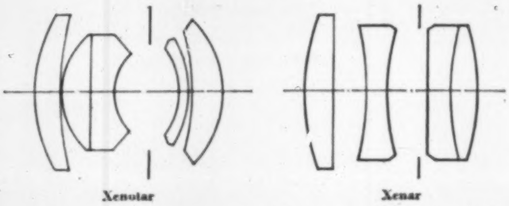
UNITED ELECTRIC *manufactures a complete line of temperature, pressure, and vacuum controls. For applications requiring custom-built units or modified standard units, call upon a UE application engineer for recommendations. Complete data is available for the Type J51 as well as for all standard UE controls.*

UE®
United Electric Controls
COMPANY
85 SCHOOL STREET WATERTOWN MASS

CIRCLE 38 ON READER-SERVICE CARD

ICS BRIEFS

Schneider Lens Types

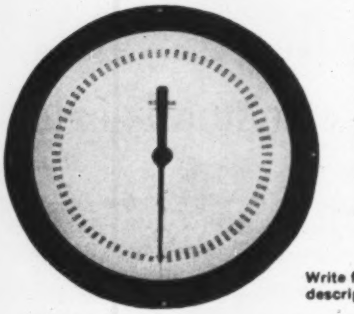


Xenotar Xenar

Xenotar general purpose lenses: High speed Xenotar lenses may be used at full aperture, providing full illumination over the entire field, and at extremely high degree of resolving power for both color and black and white. Optimum image quality is reached at f:4. Focal lengths 80 to 150mm. Design: four air spaced components of five glasses (three single lenses and a cemented pair) . . . . *Xenar* general purpose lenses: A very well corrected standard lens of four glass construction (two cemented lenses and two air spaced). The design of the long popular Xenar affords excellent light transmission, very fine definition with brilliant contrast and separation of tones for color or black and white. Focal lengths 105 to 480mm . . . (*From new 28-page Catalogue Part 2, 1960, Burleigh Brooks Inc., 420 Grand Ave., Englewood, N. J.*)

FOR THIS LITERATURE CIRCLE 162 ON READER-SERVICE CARD

PRECISION TEST GAUGES



Designed for the Ultimate in Accurate Pressure Measurement

Write for
descriptive brochure M-28A

Consider These Advantages:

- 360° Calibration provides 25% greater scale length.
- Saves over 115 square inches of panel space.
- Ni-Span C Bourdon tube is temperature stable.
- Tube tip bleed is standard equipment.
- .15% full scale accuracy.
- Movement calibrated to dial, uniform increments.
- Capacities to 15,000 psi.

Write For Descriptive Bulletin AR 31

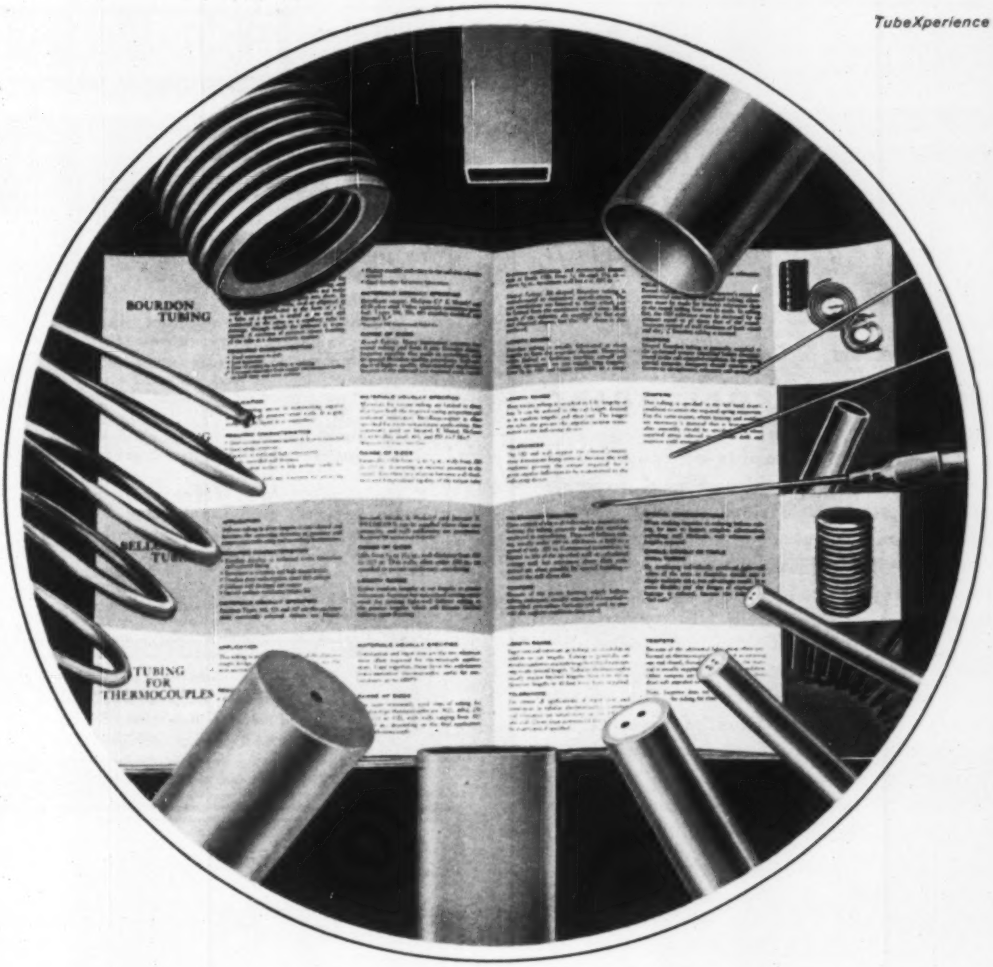
MARTIN DECKER

Martin-Decker Corporation
3431 Cherry Ave., Long Beach 7, Calif.

Precision Pressure Instruments — Testing — Weighing — Load and Force Measurement

CIRCLE 39 ON READER-SERVICE CARD

TubeXperience in action



TUBEXPERIENCE PREPARES A NEW INSTRUMENT BULLETIN —GUIDE TO SELECTION AND APPLICATION OF INSTRUMENT TUBING

Superior's long experience in producing small-diameter metal tubing to extremely close tolerances enables it to offer instrument designers and makers a wide variety of materials, sizes, metallurgical competence, and manufacturing skills that save experimentation in the design stage . . . time and cost in production.

"Specialty Tubing for Industrial Instrumentation"—a new bulletin by Superior just off the press—puts into print for the first time comprehensive information that covers all types of Superior tubing for the instrument field. It includes required characteristics, materials usually specified, range of sizes, tolerances, tempers, and special considerations for thermometer-bulb, capillary, Bourdon, bellows, fire detection, linkage, recording-pen and torque tubing; also tubing for thermocouples and gas chromatography.

Send for a copy of this valuable bulletin today. The information covered will greatly help your selection of tubing for all measuring, indicating, recording and control devices. If you have a problem involving tubing, call on us to help you solve it. Superior Tube Company, 1968 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to $\frac{5}{8}$ in. OD—certain analyses in light walls up to $2\frac{1}{2}$ in. OD

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

CIRCLE 40 ON READER-SERVICE CARD

Manufacturers–Reach more buyers and users of your measurement and control equipment, systems, and components—more often through—

Instruments & Control Systems

1961 BUYERS' GUIDE

Distribution—36,000 copies—to engineering management and technical personnel responsible for design, specification, purchase, application and maintenance of instruments, systems and devices for measurement, inspection, testing, analysis, computing, and automatic control.

Your ad receives "close to listing" position . . . a feature made more useful to you through the "sectionalized" format of the '61 Guide. Your products can be displayed in one or more of these nine sections (below), or in conventional front or back of book locations.

Industrial Control Instrumentation
Data Handling and Recording
Electrical and Electronic Instruments
Analytical and Laboratory Instruments
Land, Sea, Air Systems and Devices
Physical Properties Test Equipment
General Engineering Instruments
Measurement and Control Components
Machines and Materials

Your catalog inserts, multi-, single-, or fractional-page ads will bring you greater return*—from the people you want to reach—in ICS 1961 Buyers' Guide.

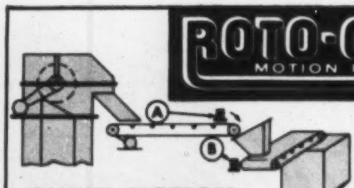
Reserve your ad space now. Call any of our district offices (see page 1072) or write direct. Closing date August 29, 1960; publication October 1960.

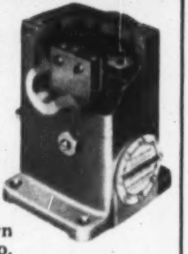
ICS 1961 BUYERS' GUIDE

845 Ridge Ave., Pittsburgh 12, Pa.

*1960 Guide (with only 9 months service under its belt) brought advertisers twice the leads of any previous edition!

ROTO-GUARD
MOTION INDICATOR





SHAFT MOTION INDICATOR

PROTECTS MACHINERY BY INDICATING STOPPAGE DUE TO OVERLOADING OR MALFUNCTION

A and B: On end return idlers, warn if conveyor should break, slow or stop.

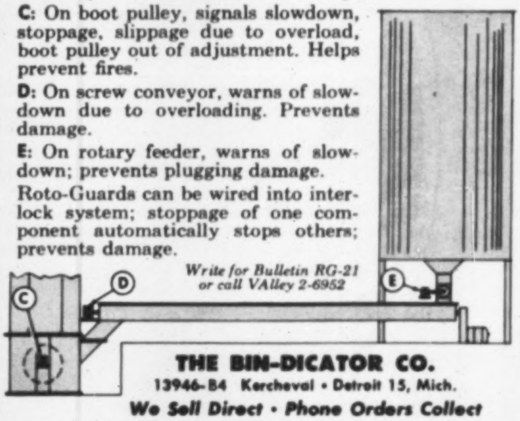
C: On boot pulley, signals slowdown, stoppage, slippage due to overload, boot pulley out of adjustment. Helps prevent fires.

D: On screw conveyor, warns of slowdown due to overloading. Prevents damage.

E: On rotary feeder, warns of slowdown; prevents plugging damage.

Roto-Guards can be wired into interlock system; stoppage of one component automatically stops others; prevents damage.

Write for Bulletin RG-21 or call VAlley 2-6952



THE BIN-DICATOR CO.
13946-B4 Kercheval • Detroit 15, Mich.
We Sell Direct • Phone Orders Collect

CIRCLE 41 ON READER-SERVICE CARD

Special Purpose Wire

titanium
phosphor bronze
BERYLLIUM COPPER
Silvercote ®
ALUMINUM
ni-clad-ti
NICKEL CLAD TITANIUM WIRE
FOR CERAMIC-TO-METAL BRAZING

• OTHER NON-FERROUS

Consider WIRE and the importance of its function in your product. Whether a highly engineered application or a simple stapling purpose, your choice of the proper alloy or composition, temper and type of wire could mean success or failure during crucial test.

round ● flat — square ■ half-round ◓

Precision gauges from ⅛ to .002. Close tolerances held.

SPRING WIRE — WIRE FOR INSTRUMENTS
ELECTRONICS — STRAND FOR WIRE ROPE AND BRAIDED APPLICATIONS — MANDREL WIRE — WIRE FOR FORMS
RIVETS — STAPLING

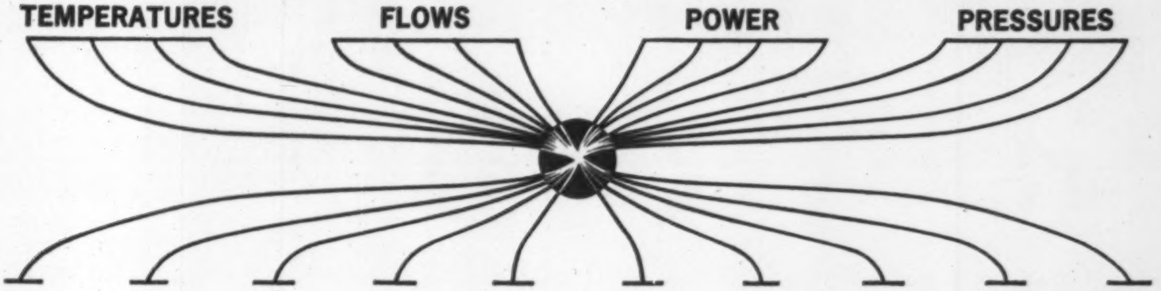
Send for descriptive folder.

LITTLE FALLS ALLOYS INCORPORATED
179 Caldwell Avenue • Paterson 1, N. J.

LFA

CIRCLE 42 ON READER-SERVICE CARD

KYBERNETES SERIES 2000



Gross Sta. Gen. (KwHr) X 1000	Net. Sta. Out. (KwHr) X 1000	Sta. Load (Kw) X 100	Bus Volt. (V) X 10	Sta. Heat Rate (Btu/KwHr) X 10	Turb. Throt. Press. (psig) X 10	Turb. In. St. Temp. (°F) X 10	Cond. Circ. W. Temp. (°F) X 0.1	Feed Water Flow (lb/hr) X 10,000	Feed Water Press. (psig) X 10
225	195	303	416	870	225	105	619	130	250
225	195	303	416	870	225	105	618	130	250
224	195	302	416	870	224	104	620	130	250
225	195	303	416	870	225	105	619	130	250

DATA PROCESSING SYSTEM

√ MORE FEATURES
√ GREATER FLEXIBILITY
√ HIGH RELIABILITY

Here are the specifications . . . check how much more you get—in Kybernetes

1. Inputs—May be AC, DC, or Digital. Input range—zero to 10 millivolts minimum full scale; 0 to 1 volt maximum full scale.
2. Input Selection—Relay matrix type—individual hermetically sealed plug-in relays.
3. Remote Selector Switch—The input selector switch may be located remotely.
4. Analog to Digital Conversion—Electronic sweep voltage technique.
5. Linearization—Special linearization functions for all types of thermocouples are available. Linearization is to ±1°F over the full range of the thermocouple type.
6. Read-out and Control Panel—Rack mounted as standard, or remote console mounted. Special functions available as required.
7. Output Devices—Typewriters, adding machine type printers, tape punch, card punch or magnetic tape systems.
8. Programming—Pin board programming is standard for full scale ranging, zero suppression, alarm set points (high and/or low), trend logging and function programming. The latter includes provision for linearization, square root extraction, amplifier gain, number of digits logged, computations, and associated requirements.
9. Alarm Comparison—Alarm comparison is accomplished by the digital comparison of the output of the analog to digital converter against the set point established on the pin board programming system. Alarm protection is in operation 100% of the time.
10. Frequency of Periodic Log Cycles—Adjustable from OFF, 5, 10, 15, 30, and 60 minutes. Continuous or single cycle logging available from the on-demand log pushbuttons.
11. Input Capacity—Expandable from 10 inputs up in multiples of 10.
12. Rate of Scanning—Four points per second for off-normal conditions when no other functions are in operation; 3 to 4 points per second for off-normal scanning when auxiliary operations are in effect. Logging at one point per second as standard; other output devices in accordance with the capacity of the device up to four points per second.
13. Integration Sampling Rate—Each point every 10 seconds.
14. Special Sampling Rates—Higher sampling rates available through parallel operation. Simultaneous real time read-out of any quantity of variables available through individual analog storage devices at the input to the system.
15. Hazardous Locations—The system is designed for operations in Class 1, Division 2, Locations (Group D atmospheric mixtures), as defined in the 1956 National Electric Code, the Standard of the National Board of Fire Underwriters.
16. Power Requirement—120 volts, 50 or 60 cycles, single phase, 600 watts. A Zener diode referenced power supply provides a regulated output to within ±0.01%.
17. Accuracy—Over-all accuracy is ±0.1% of full scale. The following tabulation will be useful in evaluating the stability and accuracy of the Kybernetes data systems.

	Maximum drift—%	
	24 hrs.	6 mos.
Chopper Amplifier	.02	.16
Sweep Generator	.05	.07
Comparator	.0016	.0016
Pulse Generator	.001	.001
Gaging Function	.001	.001
Counters in Storage	.000	.000
Reference Voltages	.01	.01
Reference Oven (Thermocouples only)	.06	.06

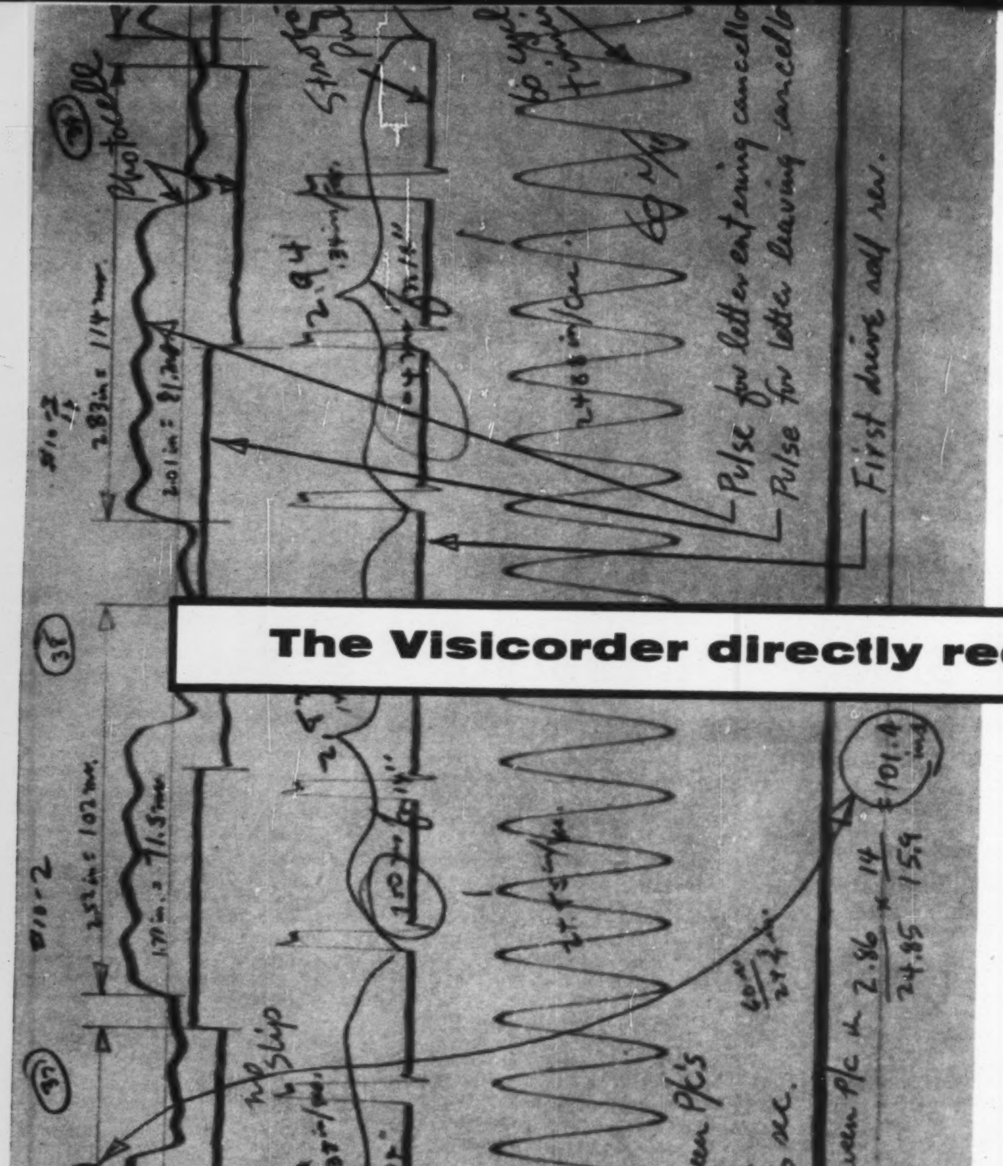
Write for Kybernetes Bulletin MSP-161 today!

HAGAN
CHEMICALS & CONTROLS, INC.
HAGAN CENTER, PITTSBURGH 30, PA.

HAGAN DIVISION: CALGON COMPANY—HALL LABORATORIES—BRUNER CORP.

CIRCLE 43 ON READER-SERVICE CARD

The Visicorder directly records



Unretouched Honeywell Visicorder record, actual size.

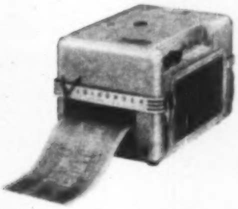
The Emerson Research Laboratories at Washington, D.C., directly-recorded this chart on a Honeywell Model 906 Visicorder. The chart shows a canceller test of a number of letters through a new mail-handling machine developed by Emerson for the U.S. Post Office Department.

In this test, the Visicorder took only 3 hours to reveal information that would have taken 3 weeks to get by any other means: what factors were responsible for the changing speeds of letters as they traveled through the machine at the rate of 30,000 letters per hour. Constant letter-travel speeds were necessary in order to register the cancellation mark on the stamp every time.

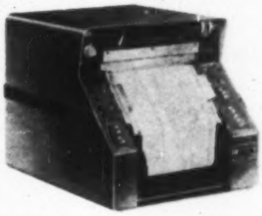
This Visicorder record revealed that motor speed variations, belt slippage and slippage of the letter in the drive rollers were responsible. A synchronous drive motor, a timing belt drive and a better grade of rubber in the drive rollers were added to solve the problem—at a vast saving in engineering time.

Milton Stovall, Emerson Project Engineer, uses the Visicorder to measure roller bounce caused by various letter thicknesses, and the consistency of letter speed through the new Emerson Automatic Mail Cancelling and Facing Machine.

high-speed letter travel



Recent Models of the 906 Visicorder incorporate time lines and grid lines and record up to 14 simultaneous channels of data.



The NEW Model 1108 Visicorder, with many automatic features and the convenience of pushbutton controls, is ideal for intermediate uses requiring up to 24 channels of data.

The Model 1012 Visicorder is the most versatile and convenient oscillograph ever devised for recording as many as 36 channels of data.

The Honeywell Visicorder is the pioneer, completely proven, and unquestioned leader in the field of high-frequency, high-sensitivity, direct-recording ultra-violet oscillography. Here are some of the reasons why Visicorders provide the most accurate analog recordings available: constant flat response and sensitivity of galvanometers; grid-lines simultaneously recorded with traces to guarantee exact reference regardless of possible paper shift or shrinkage; flash-tube timing system for greater accuracy of time lines; superior optics for maximum linearity of traces.

No matter what field you are in . . . research, development, computing, rocketry, product design, control, nucleonics . . . the high-frequency (DC to 5000 cps) Visicorder Oscillograph will save you time and money in data acquisition.

Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Reference Data: write for Bulletins 1108, 1012, and HC906B

Minneapolis-Honeywell Regulator Co.
Industrial Products Group, Heiland Division
5200 E. Evans Avenue, Denver 22, Colorado

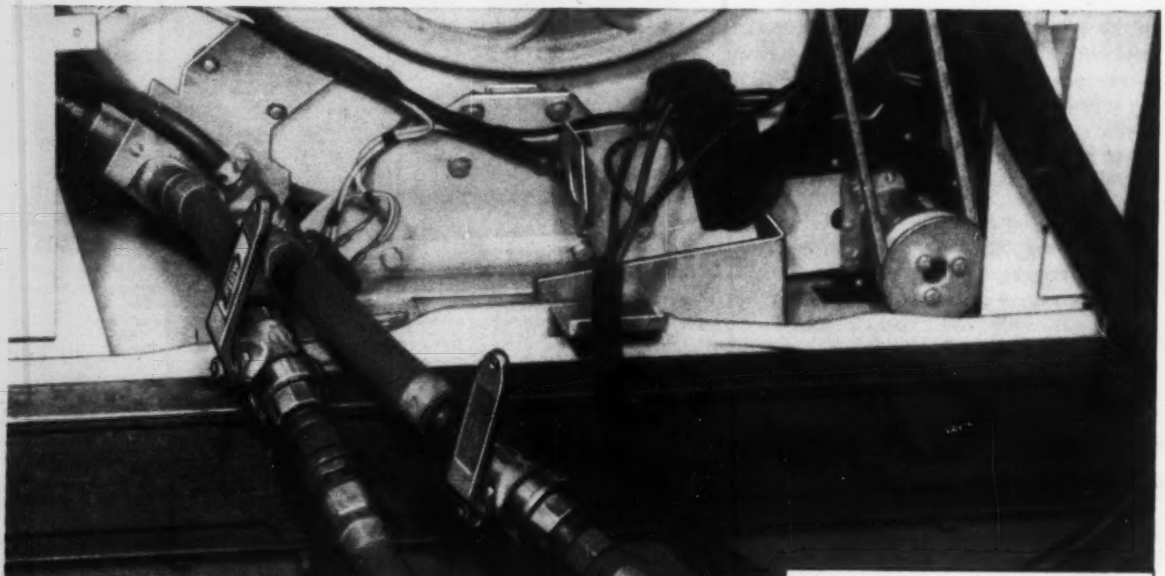
75th YEAR PIONEERING THE FUTURE

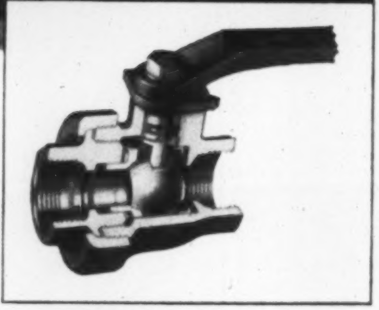
Honeywell

H Industrial Products Group

CIRCLE 44 ON READER-SERVICE CARD

HUNDREDS OF THOUSANDS OF TURNS AND 2 YEARS LATER . . .





Rockwood Ball Valves are STILL ON THE JOB!

In the Easy Laundry Appliances Division, The Murray Corporation of America, Rockwood Ball Valves prove their dependability day after day. Used in the 100% testing of the famous EASY Golden Regent automatic washing machines for water load, leakage and rinse cycle selections, these ½″ Ball Valves are opened and closed hundreds of times a day. Now after two years in operation, these Rockwood Ball Valves are still leakproof and require no maintenance.

Their full, round flow, tight seal and smooth, easy opening and closing features provide the highly efficient valve performance required by this manufacturer.

You too can depend on this same efficiency with Rockwood Ball Valves that are designed and engineered to give longer, trouble-free service.

Consider these four exclusive features when you're thinking about your own valve problem:

1. Only valve with full, round flow — valve opening same diameter as pipe . . . causes no turbulence.
2. Leakproof — even after continued use.
3. Quick opening and closing — with quarter-turns under full pressure.
4. Longer life — longer periods between replacement and no maintenance.

Rockwood Ball Valves are today giving outstanding service in oil refineries, food, paper, textile, chemical and rubber plants. Valves are available in pipe sizes from ½″ to 10″ with 300 p.s.i. working pressure. For further information regarding your use of Rockwood Ball Valves, send coupon today. Tested and listed by Underwriters' Laboratories, Inc. Distributors in principal industrial areas.

CIRCLE 45 ON READER-SERVICE CARD

ROCKWOOD BALL VALVES

The Only Valve with FULL, ROUND FLOW

ROCKWOOD SPRINKLER DIV.
of The Gamewell Co.
A subsidiary of E. W. *Bliss Co.*
1027 Harlow Street
Worcester 5, Massachusetts

Send me illustrated booklet on the complete line of Rockwood Full-Flow Ball Valves

Name ....

Title ....

Company ....

City .... *Zone* .... *State* ....

ICS PANHANDLE PETE

Announcing New Manualization Division

WESCO! announces a new division—the manualization division—whose first product is a simple, knife- or adze-like cutting tool. Its use by a major wood-furniture making firm has reduced machinery investment requirements by two-thirds, saving $42,000 the first year alone, while substantially improving quality of the firm's products.

The firm—reported to have made great strides towards manualization in recent years in economically-distressed area—states it now accomplishes in three weeks, with 600 workers, what formerly took five expensive planers, shapers and sanding machines a full day's time to achieve.

At the same time, artistic quality and individuality restored to the tables, chairs, sideboards and other products by hand-working have quadrupled demand for the company's products, sold mostly in the arts-and-crafts-conscious American market.

Specific benefits cited by the firm include:

Two-Thirds Reduction in Machine Requirements. Inexpensive hand labor replaces automatic machinery in shaping and finishing furniture. Capital equipment saving, $38,400 plus lower electric charges.

Eliminates Three Material Handling Steps. Incoming materials now move direct from the sawmill to the workmen, who complete all operations except worm-holing, staining, and packing. Savings: an estimated $3600 annually.

Reduced Quality-Control Requirements. Fourteen quality control inspectors, freed for reassignment, have been given the knife.

An immediate drop of 7% unemployment in the economically hard-hit area has been a gratifying bonus benefit.

The new tool is extremely simple in concept. It consists, essentially, of a 10" to 12" high-carbon or alloy steel blade projecting—adze-like—from a wooden handle, which is provided for the comfort of the operator. Low in cost and requiring virtually no maintenance, other than sharpening, the modified adze was developed by WESCO's Advanced Systems Group.

The design was primarily intended for application on a new line of genuine Early American antique furniture being developed for the export market. Results were so good, the tools were adopted plant-wide, and are now being marketed by the new division.

The adze-like tool meets Government specifications (MIL-B-974033) for production equipment to be used in economically distressed areas.

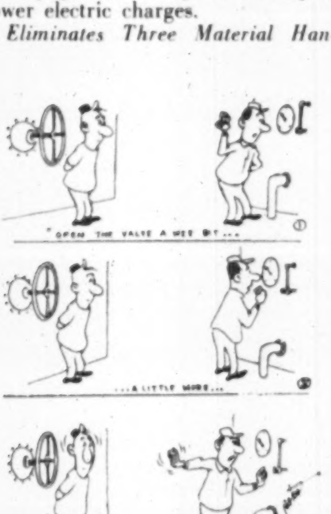
Operation is readily taught. The operator—sitting, standing, or kneeling—grasps the tool firmly in his right hand. If the operator happens to be left-handed, this procedure can be readily reversed.

The sharp edge of the blade is then applied to the workpiece in long stroking motions and according to the pattern desired.

Officials of a number of other woodworking plants have visited to witness the new operating procedures, and are now considering adoption of WESCO's half-adze production methods.

Panhandle Pete

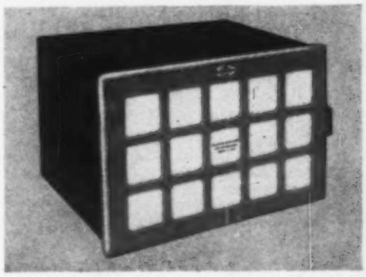
(The assistance of Mr. James Long, of the Advertising and Public Relations Firm of Gray & Rogers in this program is gratefully acknowledged.)


"OPEN THE VALVE A WEE BIT...
①
...A LITTLE MORE...
②
...THAT'LL DO IT!"
③

Judging by the Company We Keep...

. . . "the Company We Keep" are fastidious in their purchases of Custom Control Systems. They demand the best, the most flexible and the most dependable alarm systems for their process control centers.

The Electro-Mech "UNIVERSALARM" annunciator has gained a good deal of attention by instrument engineers in the major industrial companies. These are men who *know the difference*, a discerning group of specialists who understand and insist upon the most advanced and most capable instrumentation available.



ELECTRO-MECH "UNIVERSALARM" ANNUNCIATOR

If you are interested in the finest of annunciation equipment, we suggest that you join "the Company We Keep" and request further information on this unusual alarm system, which has *built-in* ability to respond to changing plant requirements without radical circuit revision.

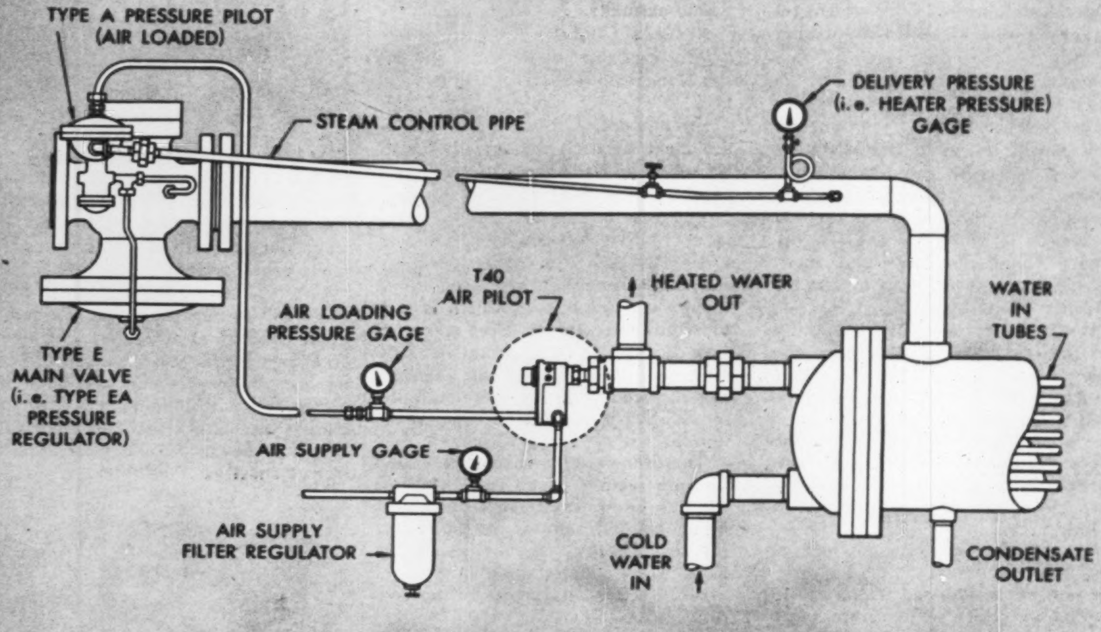
Electro-Mech Corp., Norwood, N. J.

Electro-Mech

CIRCLE 47 ON READER-SERVICE CARD

CONTROL TIPS:

New Spence Temperature Control System with Cascade Control Accuracy at Regulator Costs


TYPE A PRESSURE PILOT (AIR LOADED)
STEAM CONTROL PIPE
DELIVERY PRESSURE (i.e. HEATER PRESSURE) GAGE
T40 AIR PILOT
HEATED WATER OUT
WATER IN TUBES
AIR LOADING PRESSURE GAGE
TYPE E MAIN VALVE (i.e. TYPE EA PRESSURE REGULATOR)
AIR SUPPLY GAGE
AIR SUPPLY FILTER REGULATOR
COLD WATER IN
CONDENSATE OUTLET

TYPE EAT40 AIR-CONTROL TEMPERATURE REGULATOR (Patent Pending)

In a recent installation the new Spence air-control temperature regulating system provided:

- ±5°F control accuracy under wide and instantaneous load swings of 210 to 80 gallons per minute.
- Up to 50% reduction in cost as compared to instrument systems of similar accuracy.

This unique cascade-type control with throttling range adjustment independent of maximum heater pressure was developed to meet today's demand for greater control accuracy.

Additional features of the new Spence Temperature Control System include:

- 200°F wide adjustable temperature range
- Adjustable speed of steam pressure change
- Over and under temperature protection
- Pressure limit control
- Fast response
- Very low air consumption
- Field reversible for heating or cooling

The Spence Type EAT Air Control Temperature System, when properly installed, will tame wide ranging, fast changing loads of instantaneous heaters and modern heat exchangers. The cascade principle plus the use of an extremely fast responding bi-metal temperature sensing element reduce time lags and provide control stability.

Here's how the new Spence system operates:

Quick response is based on a bi-metal temperature sensing element.

Temperature pilot continuously regulates a loading air pressure.

This loading signal, when applied to a pressure regulator to reflect heater temperatures, causes it to adjust the main valve as changes in load require.

Spence has also developed a new pressure control system based on this same cascade principle. This system has a control accuracy of ½ psi or better from positive pressures through the vacuum range to 30" Hg.

For complete information on these new air controlled temperature and pressure control systems, write for your copy of Bulletin 9.

SPENCE ENGINEERING COMPANY, INC.
Walden, New York

SE-140A

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HOKE **Flow Sheet** 2

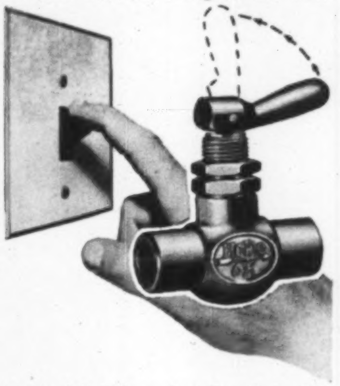
HOKE REPORTS ON FLUID CONTROL

WE'VE PACKED PERFORMANCE IN A PACKLESS VALVE

How to be "Flip" About On-Off Control

We've turned the tables on electrical engineering profs who try to demonstrate current flow by describing a valve on a pipe. Our switch-action toggle valves stop and start flow just as easy as: Flip, it's on! – Flip, it's off!

These valves perform a basically simple function, but a lot of engineering went into them to insure perfect performance. Many are used on precision test equipment and for control applications, often in conjunction with automatic controls as a manual safeguard for fast shut-off. Designed for both gas and liquid service, the stem seals are tight enough for most vacuum work, too. We certainly can't be flip about these specifications.



Hoke manufactures two types of toggle valves. The 450 Series has maximum operating pressures up to 200 psi. These are spring closing valves made in ¼" and ⅛" pipe sizes which can be classified as "miniatures", measuring less than 2" in height in the closed position. They are normally supplied with moulded, black, Nylon handles, but colored handles can be supplied for special identification purposes. Panel mounting lock-nuts are included as standard equipment on every valve.

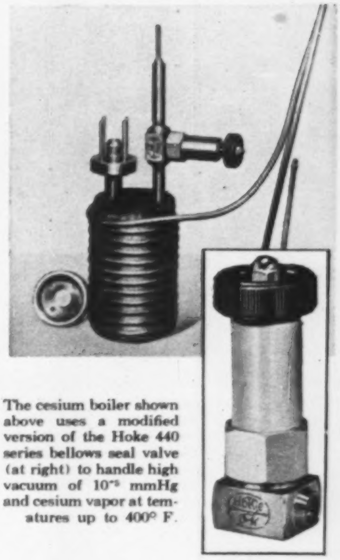
The second type is the 490 Series, a cam-closing toggle valve for service up to 2000 psi. They'll give you the same quick, positive action as the 450 Series, while performing the toughest laboratory and process jobs. The 490 and the 450 are excellent performers on non-critical high vacuum. They can be helium leak-tested for this purpose.

So, if you're interested in switch-action flow control, investigate the Hoke toggle valves. We'll be happy to equip you with complete technical data. A check in the coupon to the right will bring you the facts.

The development of packless valves has so greatly reduced the problems of handling high pressures, temperatures and vacuums, and dangerous fluids that engineers designing such systems can now spend more time curled up with the Hoke Corrosion Chart.*

With this extra time, many have dreamed up weird applications for the Hoke 440 Series bellows seal valve, trying to snare us in our own semantics. In a rash moment, we boasted that this valve could be modified for almost any application. Actually, the 440 can be modified to work at high pressures (up to 2000 psi), for high temperatures (up to 1000°F.), and for special connections such as tubing, socket welding, and silver brazing.

Aside from this horn-blowing, here are the dry facts. The basic design includes a stainless steel body, inert arc-welded bellows assembly, Teflon gaskets and Teflon stem point discs. This is only the starting point. Minor modifications make so many models available that almost any problem, including liquid metal handling, can be solved.



The cesium boiler shown above uses a modified version of the Hoke 440 series bellows seal valve (at right) to handle high vacuum of 10^{-5} mmHg and cesium vapor at temperatures up to 400° F.

Hear what a disbeliever said: "I did not believe that the modified valves would satisfy all my requirements, especially to keep a high vacuum of the order of 10^{-5} mmHg under a wide variation of temperatures; however, I now acknowledge that the modified Hoke 440 valves fulfilled their duty perfectly." This came from The Martin Company, where we sent 440's for use in cesium vapor up to 400°F. Special modifications made these valves readily usable on a cesium boiler and converted an infidel to the true valve.

If you work with critical high vacuum, high pressures, high temperatures and dangerous fluids, proceed with care. Ask for our Packless Valve Bulletin to reap a harvest of engineering plums.

** Makes good reading if you're handling corrosive agents. Write, and we'll send you one.*

FREE! A STEADY FLOW OF FACTS!

Further flow features, and interesting technical topics are carefully covered in Hoke's technical publication, the FLOW SHEET. It's free, but worth millions! To get the full benefit of our engineering and editorial efforts six times a year, mark your "X" in the proper box.

Hoke's Performance Guarantee — *Every Valve Leak-Tested!*

HOKE INCORPORATED
31 Piermont Road, Cresskill, N. J.

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- ☐ **Toggle Valves**
- ☐ **Flow Sheet**
- ☐ **FREE Corrosion Slide Rule**
- ☐ **Complete Catalog GC 959**

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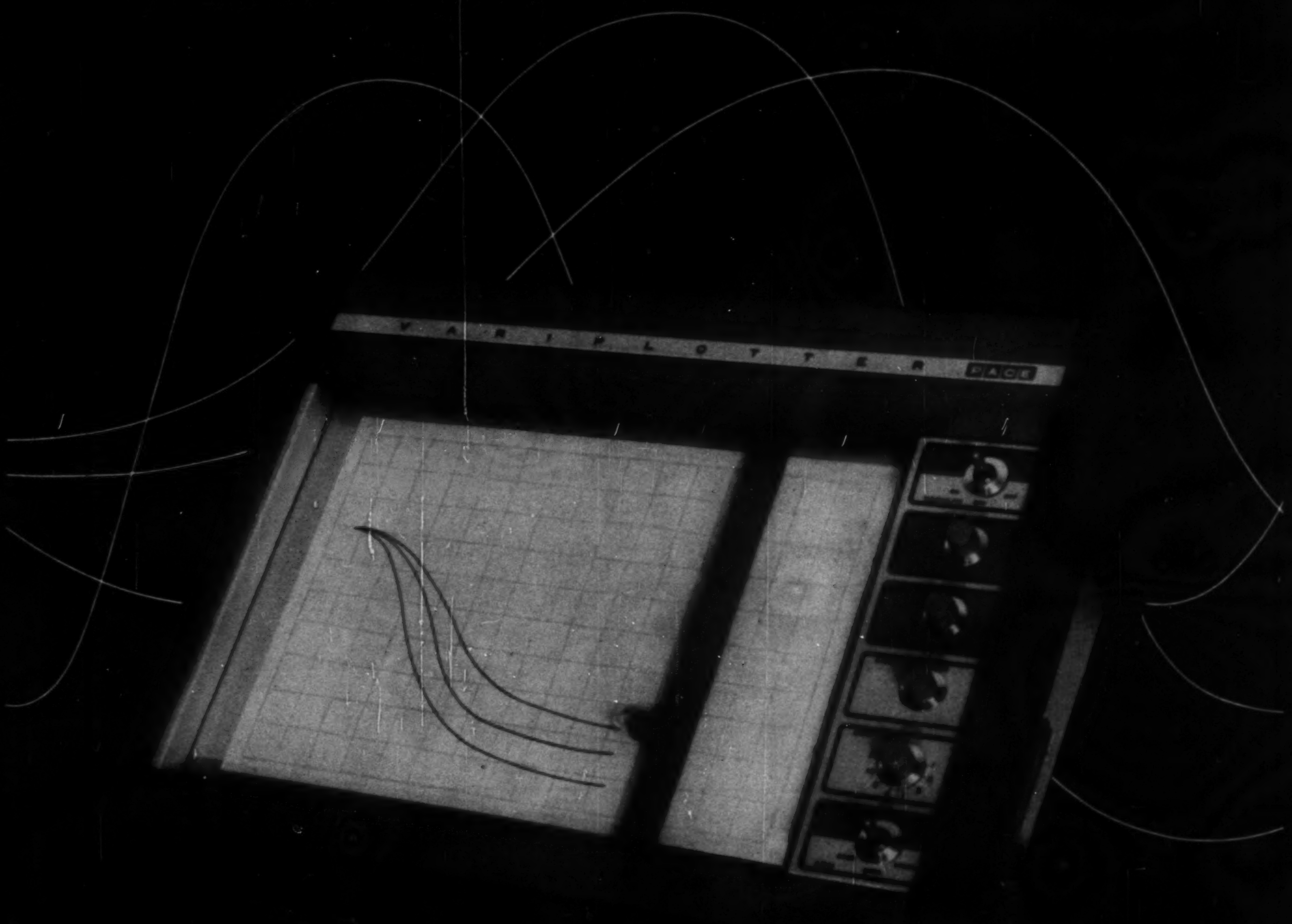
VARIPLOTTER
PACE

VARIPLOTTER, MODEL 1100E

EAI

ELECTRONIC ASSOCIATES, INC. *Long Branch, New Jersey*

The SIMULATION COUNCIL Newsletter

John H. McLeod Jr., EDITOR
Suzette McLeod, SECRETARY
8484 La Jolla Shores Drive,
La Jolla, California

Simulation Councils, Inc.
Stan Rogers, Convair, San Diego, Calif.; Chairman, Board of Directors

Western Simulation Council
George Bekey, Space Technology Laboratories, Los Angeles 45, Calif.; Chairman Steering Committee

Midwestern Simulation Council
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Bits

This month we got letters (from *R. E. Rockwell*, *B. G. Zimmerman*, and *H. F. Meissinger*); we got a complete technical article (from there we go to PIECES).

Under PIECES we finish telling you about the Western S/C Navy Electronics Lab meeting in January as we comment on *George Merrick's* story of the X-15 simulation, and attempt a combined summary of *Duane McRuer's* "Human Operator as a Servo System Element" and *George Bekey's* "Mathematical Models of the Human Operator."

And as if that weren't enough, we tell you all we know (or rather understand) about the Southeastern S/C meeting at Georgia Tech last January where *R. S. Johnson* spoke on "Plotting Nyquist Diagrams on an Analog Computer," and *N. C. Seiler* gave a paper on "Application of the Z-Transform in the Simulation of Sampled-Data Control Systems."

Enough!

Letters

"Dear Mr. McLeod:

"The process control laboratory I wrote to you about is intended to supplement the course work given on automatic control. We will certainly welcome any help you or your readers can give us on this subject. At present this is in the planning stage.

"Suggestions for the lab should be addressed to Professor H. H. Young, Industrial Engineering Department, here at Purdue."

R. E. Rockwell
219-B Fiers Mobile Park
West Lafayette, Indiana

☆ ☆ ☆

"Dear Mr. McLeod:

"In reference to Mr. Whitaker's simulation of non-linear devices (S/C *Newsletter* March 1960) the following alternative methods come to mind. The circuit in Fig. 1(a) gives a pretty good approximation to the response indicated in Fig. 1(b). Since the settings of V_1 and V_2 are rather sensitive, a small resistance could be added at the point x if some loss in flatness over the zero portion of the curve can be tolerated. Using this circuit, the bidirectional relay could be simulated as in Fig. 2(a), or sharper response could be obtained using Fig. 2(b). The clutch

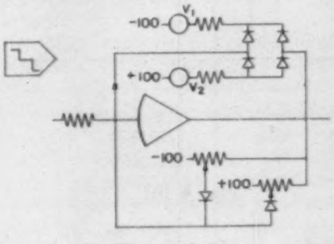

Fig. 1 (a)

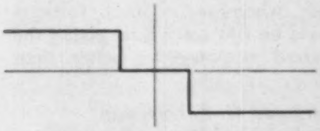

Fig. 1 (b)

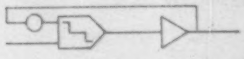

Fig. 2 (a)

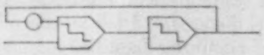

Fig. 2 (b)

← CIRCLE 50 ON READER-SERVICE CARD

could be simulated as in Fig. 3 with a saving of two amplifiers, or it could be simulated by a single amplifier as in Fig. 4(a). The actual response of Fig. 4(a) is as

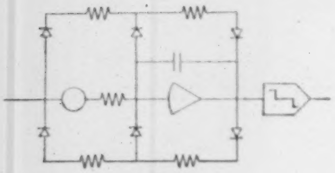

Fig. 3

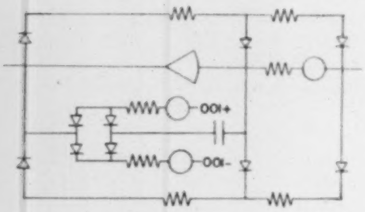

Fig. 4 (a)

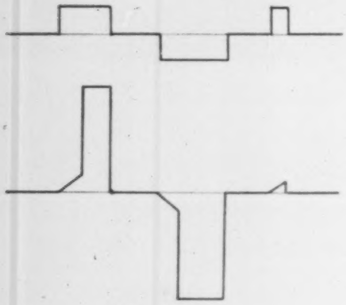

Fig. 4 (b)

shown in Fig. 4(b), but the height of the ramp could be less than 0.5 volt, whereas the limit voltages could be 100 volts, thus giving the desired response to better than 0.5%."

Benjamin G. Zimmerman
Applied Mathematics Branch
Mechanics Division
U. S. Naval Research Laboratory
Washington 25, D. C.

☆ ☆ ☆

"Dear John:

"The following are a few notes which summarize an interesting informal discussion I led on the subject of computer facilities management during one of our recent Simulation Council meetings. The last Simulation Council *Newsletter*, having given considerable space to this subject, reminded me that I had never transmitted this material to you. Perhaps there is still some use for it at this late date.

1. Staffing of a Computer Facility

"Norair has a centralized facility including all engineering digital and analog computations and some digital data processing. The policy is one of complete interchangeability of computer personnel. All members of the staff can program both analog and digital computers. Apparently this results in a lack of specialization which may hurt efficiency in some phases of operation.

"Other computer facilities have had excellent results from assigning personnel of non-professional type to the more mechanical phases of computer programming and operation to relieve skilled professionals of some of the time-consuming work involved. The benefits of this approach are cost savings and greater job satisfaction all around. A similar attempt has recently been made at the Hughes Systems Analysis Laboratory's facility and looks promising.

2. Maintenance of Analog Computers

"The maintenance load factor for a technician in a typical analog computer facility is approximately 60-80 amplifiers per technician. One extreme case (The Jet Propulsion Laboratory in Pasadena) had one technician for every 20 amplifiers, justified by a number of equipment development projects.

3. Activities Involving 'Bread-and-butter' Projects versus Advanced Application Projects

"The consensus of opinion was that everyone likes to further the state of the art to be able to apply the results to future business, but the question of funding and manpower availability usually arises. Convair-Pomona solves this problem in their centralized computer facility by keeping an account of 'bread-and-butter' projects and conducting just as much of the advanced application work as is feasible to remain economically solvent. This facility charges its customers a fixed amount per hour of computer service, which includes a reasonable margin for overhead. They use a general fund for so-called unidentifiable projects. On the average the manpower expended by various computing facilities on projects came to 10-20% of the total.

4. Establishment of Priorities in Computer Projects

"Most facilities are subjected to the same pressures on productive output as the Hughes Systems Analysis Laboratory facility, and they reconcile the demands of various groups requiring computer services by clearing their priority lists with higher management, and in some cases by distributing published lists of these priorities. The scrutiny on job priorities being applied in the Systems Analysis Laboratory facility was recognized as very desirable. Only one representative present (Norair) stated that his facility categorically refuses to get involved* in these policy matters.

5. Use of an Output Plotter in Conjunction with the IBM 704 Computer

"At Douglas-El Segundo a Tally Register Plotter (cost approximately $14,000) is used to record a majority of the data obtained. This device is considered absolutely essential, and is taken for granted by everyone involved. It has operated satisfactorily over several years but may now be somewhat obsolete. Tally has developed an improved version. (For information I was referred to Mr. *Ray Dilling*, Vice President and Chief Engineer, Tally Register, Inc., Seattle, Washington.) The unit plots families of up to eight curves in terms of discrete points from punch cards, through an off-line card reader. Mr. *W. Schliesser*, who is in charge of this facility, was greatly surprised at the suggestion that anyone might not use such plotting devices in a digital facility. His view: 'Engineers are accustomed to looking at graphical data rather than tabulated data to determine performance trends, etc.' Where accuracy greater than that of the printed record is essential, the tabulated printout sheets are used as supplement."

Hans F. Meissinger
Engineering Division
Hughes Aircraft Company
Culver City, California

---

*How?—Ed.

MEETING OF WESTERN S/C AT NEL ON HUMANS

George Merrick (North American Aviation, El Segundo, Calif.) was the second speaker on the Western Simulation Council meeting held at NEL last Jan.

Merrick on X-15 Simulation

The X-15 program, George said, was a case of putting a man in a closed loop and seeing how he could do. This program, started about 10 years ago, was designed to find a vehicle which could explore the problems of flight and the thermal consequences at very high speeds and altitudes. The flight regime was to be a state-of-the-art advancement, but the machine itself was to be based on what was already available. The human pilot fitted into the picture well. He was reliable, flexible, and maintenance was no problem.

George Merrick of North American Aviation, El Segundo

"But," said George, "We had to decide whether or not he could do the job. And we had to be sure he was properly trained."

The NAA simulation was originally developed as a means of designing a flight control system which a pilot in the loop could manage, and was subsequently used for pilot training.

George showed slides of the X-15 and the 300-400 amplifier computer which Scott Crossfield has "flown" so often. It is interesting that this X-15 simulation has been on the computer for about two years—it is never taken off! Some 38 instruments were shown in the simulator cockpit.

George also showed moving pictures of an X-15 flight which we wish we could bring you, but for this we will have to await some advances in the publishing art.

To supplement some 800 to 1000 flights of the NAA simulator, about 330 runs were made in the Navy's Johnsville centrifuge. In it the pilot was subjected to some 6-8 g's head-to-seat, and 2 g front-to-back, for 15 seconds, to simulate a 500,000-foot re-entry. After all this simulation it was decided that the pilot had experienced just about everything he would in an actual flight—except the absence of a reset switch.

McRuer on the Human Operator

Duane McRuer, president of Systems Technology Inc. and the next speaker, began his talk, "Dynamic Response of the Human Operator," explaining that because of a bout with the flu bug he felt neither dynamic nor human. Nevertheless his talk, based on "a combination of many papers and reports which have been written during the past three or four years," was well presented and served as an excellent point of departure for *George Bekey*, who followed him on the program.

Duane McRuer, President, Systems Technology Inc.

Bekey on Math Models of Humans

George's talk, "Mathematical Models of the Human Operator," was based in part on some of Duane's original work (as well as that of some 45 other references listed in his bibliography) and was arranged to complement Duane's presentation.

George Bekey, Space Technology Laboratories, and Chairman, Steering Committee, Western Simulation Council

We therefore believe that rather than try to tell you what either Duane or George actually said at the meeting, it would be more meaningful to quote excerpts from the published papers on which both talks were primarily based: "The Human Operator as a Servo System Element"*, "A Servomechanism Approach to Skill Development"**, and "Mathematical Models of the Human Operator".***

Man excels in environmental adaptability, versatility, ability to discern signals in the presence of noise and—perhaps most important—his presence makes a control system adaptive and self-optimizing. Thus, although it may be possible to eliminate the human component in many present-day control systems, in many cases it will continue to be either difficult or undesirable to do so.

However, the human being does present certain unalterable perform-

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*By *Duane T. McRuer* and *Ezra S. Kundel, Journal of the Franklin Institute*, Vol. 267, No. 5, May and No. 6, June 1959. Duane writes that copies of this and: "A Review and Summary of Tracking Research Applied to the Description of Human Dynamic Response"; "Handling Qualities of Pilot Dynamics"; and "A Positive Approach to Man's Role in Space" are available if you write him at Systems Technology Inc., 1630 Centinela Avenue, Inglewood 3, Calif.

***Journal of the Franklin Institute*, Jan. 1960.

***George says that copies of this STL report (including the 46-title bibliography, which is too long to include here) are available from him at Space Technology Labs, Box 45564 Airport Station, Los Angeles 45, Calif.

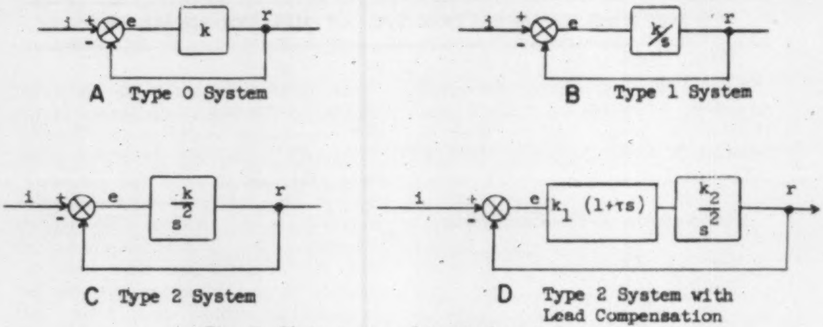
ance limitations on any system of which he is a part. These limits are due to physiological characteristics, such as the sensitivity and bandwidth of his senses, the fatigue limits of his muscular system, and the vigilance of which he is capable. In addition to these, since in any control system the man acts at least as a transducer or translator of information, his performance requires mental processes which take time and thus introduce significant delays into the system.

Systematic and successful design in any branch of engineering depends on the availability of mathematical descriptions of the processes involved.* However, the construction of an adequate mathematical model of the human operator, even for a particular task, is fraught with difficulties. The problem is that man is intermittent, time-varying, and nonlinear in his operation, and the mathematical tools for nonlinear, intermittent processes are still in their infancy.

Between a human's perception of a signal and his response there is a short period during which a second signal cannot take effect. This effect is typical of many physiological processes, and appears to be due to the basic intermittency of the sensation-response activity. Many experiments show that it is impossible to deal correctly with every stimulus in a sequence when the stimuli are closer than about 0.5 second from each other.

The basic human output in present-day control systems is the movement of skeletal muscles resulting in limb displacement or application of force. The knowledge of limb position and force output is due not only to vision but to sense organs in muscles and joints known as *proprioceptors.* The sensory outputs of these organs provide feedback signals which make possible the regulation of skilled muscular movements.

This kinaesthetic feedback is transmitted by afferent nerve fibers from the muscles to the central nervous system. The dependence of controlled movement on these fibers is clearly demonstrated if they are severed—the resulting movements are jerky and inaccurate.



A Type 0 System

B Type 1 System

C Type 2 System

D Type 2 System with Lead Compensation

Fig. 5. Basic types of control systems.

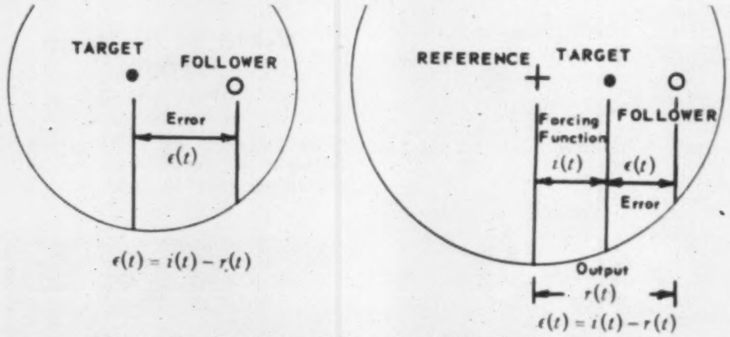


Fig. 6. Compensatory (left) and pursuit (right) displays.

Man is intermittent in his operation, his bandwidth is limited by the time required for decision and action, his senses are nonlinear, and his awareness of output movement is of limited accuracy.

In a completely linear system, stability criteria can be formulated mathematically quite simply. The presence of the human operator with his nonlinearities renders the problem considerably more complex. In the first place, the man has a sensory threshold—i.e., he does not detect errors smaller than a certain magnitude. The dead zone results in a small-amplitude limit cycle because the error will oscillate within this dead zone. If the threshold is a small proportion of the total excursion of the system, it can still be grossly stable, as far as large input signals are concerned. Secondly, man's reaction time introduces a finite time delay into the system. Any stable system with greater than unity loop gain can be made unstable by insertion of sufficient time delay into the loop. Thus, the human operator introduces destabilizing effects into the control loop, which require compensation to insure stability. Since in general the loop will be conditionally stable, the human operator is required to adjust his gain to produce optimum response consistent with stability.

The *type* of a closed-loop control system refers to its ability to reduce errors from certain inputs to zero: Consider the system of Fig. 5A with only a gain k in the forward loop. This system, known as a *type* 0 *system,* must have a steady-state error (if the output is to be other than zero) even with a constant input. The system of Fig. 5B is *type* 1 *system* and includes an integration in the forward loop. Now the loop can reduce to zero the error from a constant input because

$$r = \int e \, dt$$

and as long as an error exists, the output will change and thus reduce the error.

However, if the input is a constant-velocity signal, the system will follow with a constant error. Similarly, a *Type* 2 *system* (Fig. 5C) can reduce to zero errors from steady-state and constant velocity inputs, but not from constant acceleration inputs. Furthermore, as a Type 2 system introduces two integrations (180° of phase shift) into the system, the loop will be unstable if the gain k is greater than unity. A Type 2 system is shown in Fig. 5D with a compensation network to introduce a derivative term, thus effectively introducing some *lead,* or anticipation, into the loop.

Fig. 6 shows two kinds of displays

---

*This is not rigorously true. Your Ed. designed a three-mode pneumatic computing controller without constructing a mathematical model of the controller, and *without any description,* mathematical or otherwise, of the characteristics of the process to be controlled. This controller was developed by Leeds & Northrup and successfully used for the control of many different processes for years before the advent of electronic controllers. It can and has been done, George.—J.M.

used in tracking tests. We have seen that a tracking task in which the operator is required to follow a constant-velocity input with zero error requires a system with at least two integrations in the forward loop. If now the man is provided with a damped joystick, the control requires a single integration. This situation can be depicted as in Fig. 7A, where the mechanism being controlled is shown as a simple gain, k_2. As a Type 2 system can be stabilized with the addition of lead compensation (see Fig. 5D), the man is required to furnish at least one differentiation and one integration to obtain the desired performance consistent with stability, even if his own reaction time and nonlinearities are neglected. While the operator is capable of performing more complex operations (indicated in Fig. 7B and 7C) he can only do so by increasing his reaction time. Increased reaction time adds further phase lag to the loop, and more than one differentiation may be required for stability. Clearly, it is possible to attain a situation in which the human operator, even with reduced bandwidth, is incapable of stabilizing the loop.

The compensation is indicated as part of the man's data-processing operation in Fig. 7B. As such, it may be referred to as *feed-forward compensation*. The lead networks required may also be inserted in the feedback path as *feedback compensation*, as indicated in Fig. 7D. Now, the required differentiation takes place on the feedback signal and the man does not see the actual system error but, rather, a new error which includes an "anticipatory" term due to the rate of change of output. Similarly, the man can be relieved of the necessity of providing the integration needed to provide a Type 2 system. These aspects of the tracking system design problem are usually known as *aiding*.

If the integration shown in the operator block of Fig. 7D is added to the mechanism itself, or placed in the feedback loop, the man is relieved of the necessity of applying force continuously or in a carefully time-sequenced pattern. This process of reducing the man's task by removing integrations from his function is sometimes called "unburdening." The removal of differentiations from the man's task is called "quickening," and can take place either in a feed-forward or feedback fashion.

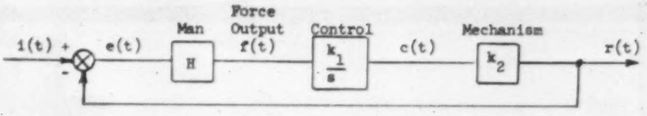
The compensation problem is unfortunately not as simple as the foregoing paragraphs imply because the nonlinearities and phase lag introduced by the operator also must be taken into account.

It may therefore be relevant to ask why the operator should be included in the loop at all. In the first place, even with all differentiating and integrating operations removed, the human still does not act as a "simple amplifier." He is still required to translate sensory inputs to motor outputs—i.e., meter deflections or spot displacements to crank motion. Clearly, this function is at least that of a transducer, rather than an amplifier.

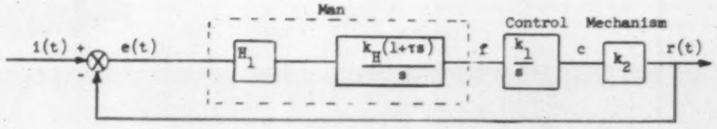
Secondly, even if the simple block diagrams do not show this, man's function in the loop is more complex and demanding than that of an information translator. Man is capable of detecting quite efficiently a signal masked by noise, even with low signal-to-noise ratios. Furthermore, man is adaptive, and his ability to function can be adjusted to the task requirement. He can monitor low-probability events and quickly adjust his gain and compensation to meet the situation. This does not imply that an autopilot could not be designed to perform all these functions. **It merely says that the versatility and adaptability of man make him a desirable component of many control situations, not merely to amplify, but to translate, interpret, compute, modify, plan, predict, guess, or perhaps to react, with his usual cussedness, in an unpredictable manner!**

It is clear that the human component is the limiting factor in the tracking loop. Adequate compensation cannot be designed unless the operator's behavior can be expressed in mathematical terms, thus making the whole loop amenable to analysis.

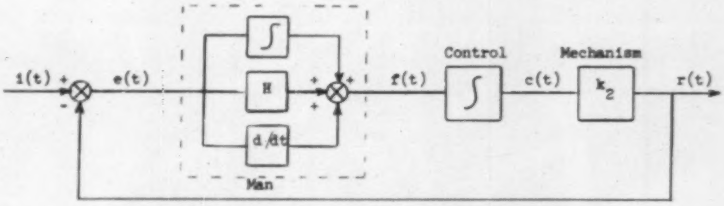
Several types of models have been proposed. The easiest model to formulate and use is a linear model with constant parameters. Unfortunately, such models cannot account for the nonlinear and adaptive behavior of man. Quasi-linear describing functions with various types of remnants are rather complex to evaluate, but agree with experimental data.



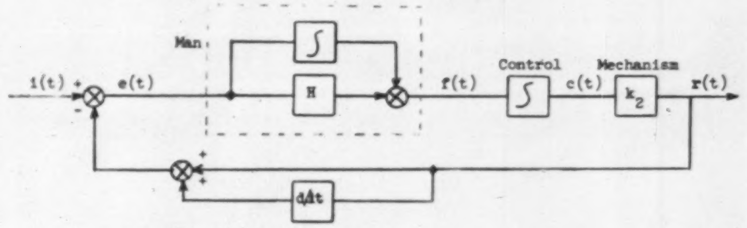
A. Tracking loop with damped control



B. Compensation required of human operator



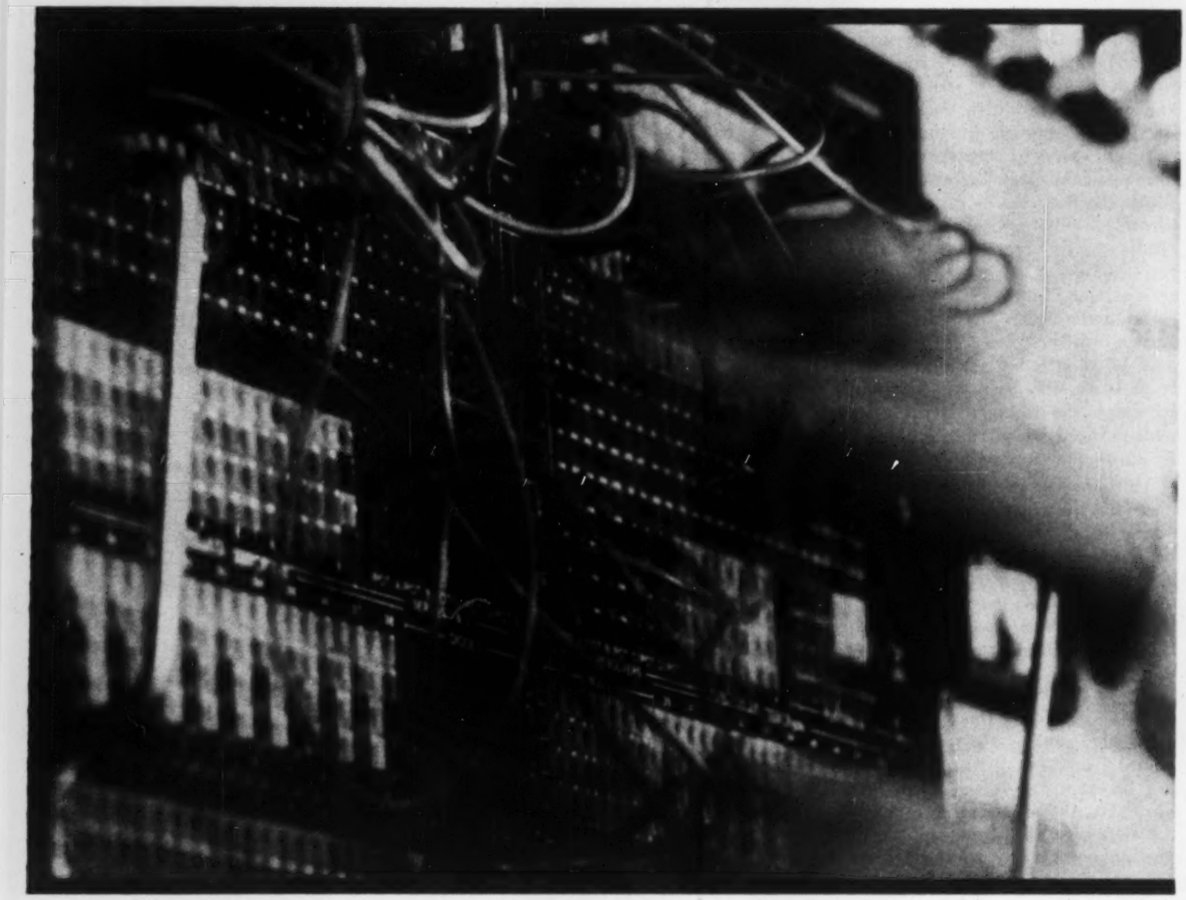
C. Equivalent diagram of operator's compensation requirement



D. Feedback Compensation

FIG. 7. Control loops with operator (B) and compensation (C and D).

DYSTAC*



A MAJOR BREAKTHROUGH IN PROBLEM SOLVING

*DYSTAC: Dynamic Storage Analog Computer, developed by CSI, incorporates high-speed repetitive capabilities with dynamic storage of analog data to an accuracy of 0.01% and with a time-base accuracy of ±0.5 microsecond. This development has tremendously increased the versatility, economy, and speed of solution associated with analog computers.

DYSTAC provides unique time-sharing of computer components and high speed reiterations. These features make possible economic and rapid solution of complex problems that have required too many computer components or too long a solution time to be considered practical for either digital or analog techniques. Different combinations of this new development readily solve problems in four broad categories.

- Sequential calculation, as encountered in the distillation problem. Here, successive solutions to algebraic matrices are obtained from cycle to cycle at a repetitive speed of 60 cps until the problem is solved.
- Definite integral calculations. Varying definite integrals are evaluated from one cycle to another and held in memory for the successful solution of optimization problems.
- Rapid evaluation of multiple integrals. This technique can be employed for the solution of partial differential equations.
- Transient problems and difference-differential equations are solved with continuous memory.

For complete information or to arrange for a demonstration write, phone, or wire:

COMPUTER SYSTEMS, INC., Culver Road, Monmouth Junction, N. J. • DAvis 9-2351

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CIRCLE 51 ON READER-SERVICE CARD

Nonlinear and adaptive models can be formulated, but require computer simulation, because general techniques for the analysis and synthesis of nonlinear systems are not available. A stochastic model has been proposed which promises to give excellent results in terms of probabilities of certain events, but cannot give transient response information directly in the time domain. Finally, sampled-data models have been suggested, which give some promise of representing correctly the intermittency and refractory period of the human operator.

A number of linear transfer functions have been formulated, and some of them give very good agreement with experimental data. In recent years the work of a number of investigators has suggested that the best linear fit to the operator's characteristics is given by the relation

$$H(s) = \frac{A(t)\,(T_L s + 1)}{(T_N s + 1)\ (T_I s + 1)}\, e^{-\tau s}$$

where T_L = lead compensation time constant, T_I = lag compensation time constant, T_N = neuromuscular system time constant, $A(t)$ = gain, τ = reaction time.

Such a quasi-linear transfer function does not account for all of the response of the system. Owing to the nonlinearities and variability of the human operator, there are usually response components which are not linearly correlated with the input. These uncorrelated components can be considered "noise" (or remnant) and added to the output of the linear transfer function, as shown in Fig. 8. The best linear transfer function (which approximates a given nonlinear characteristic) is called the *describing function.* The output of the describing function is the "best possible" linear approximation to the actual system output, in the sense of minimizing the mean square error of approximation.

There is considerable evidence that the human operator of complex mechanisms, such as a jet pilot or automobile driver, behaves as an adaptive system. Pilots are known to superimpose "dither" on their tracking motions. In effect, this small-amplitude oscillation is a succession of impulses to test the response of the system. Based on selective filtering of the response to the test signals, the pilot adjusts the loop gain.

Extensive work has been done with the formulation of a nonlinear model of the human operator which includes a number of psycho-physiological effects in explicit detail. The resulting model cannot be treated analytically and must be solved on an analog computer. The results of computer simulations give excellent agreement with measured performance data.

The proposed time-domain sampled-data model of Fig. 9 is based on the following hypothetical analysis of the operator's performance:

1. The external world is sampled for a brief period of time, just sufficiently long to overcome sensory thresholds and obtain a sufficiently accurate picture of the input e(t).

2. The hold behaves as a first-order hold—i.e., it includes a short-term memory capable of storing two past samples of information, on the basis of which a rate of change can be predicted.

3. The anticipated behavior of the error signal from the hold system is subject to whatever compensation the particular system requires.

4. The resulting signal—smoothed, processed, and delayed by one reaction time—is sent to the output system.

5. The neuromuscular system now samples the incoming information at the same frequency, but delayed by the time required for mental processing.

6. The sampled information is again held by a first-order-hold, which produces constant-rate corrective maneuvers during each sampling period.

7. These output movements are transmitted to the mechanism and reflected back through proprioceptors.

The analysis of such a time-domain model yet remains to be done. It does, however, show promise of giving a picture of some aspects of the man-machine system not given by other models. In particular, it may be possible to illustrate the refractory period of the operator, the apparent filtering of certain frequencies higher than the basic sampling frequency, the increase in apparent reaction time when input signals are placed very close in time, and the over-all problem of stability. Ultimately, however, unless some of the adaptive and nonlinear behavior of the operator can be included in the model, it will suffer from many limitations, as do other existing models.

To George Bekey it seems clear that man will successfully design himself out of many control loops in the years to come. In some cases the price may be decreased adaptability and versatility of the systems in question. Where he does remain, however, he should do so with as full a use of his amazing capabilities as possible. A simpler lever, a gear pair or a triode can be used as amplifiers, but it takes a great deal more equipment to build an adaptive, optimizing system capable of detecting signals immersed in noise, capable of modifying his mission or rebuilding the controlled mechanism, capable of anticipation, *and carrying with him an immense library of recorded knowledge.* The formulation of more adequate models of the human element in a control system should make possible a more "human use of human beings." Perhaps this is a worthy goal for the human factors engineer.

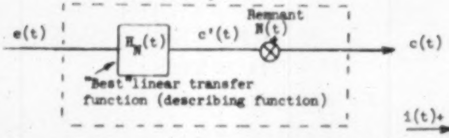

Fig. 8. Uncorrelated components at output of linear transfer function.

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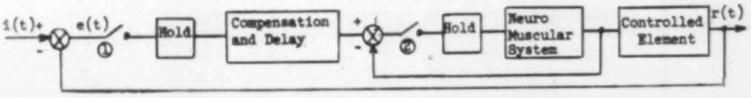
Fig. 9. Proposed sampled-data model.



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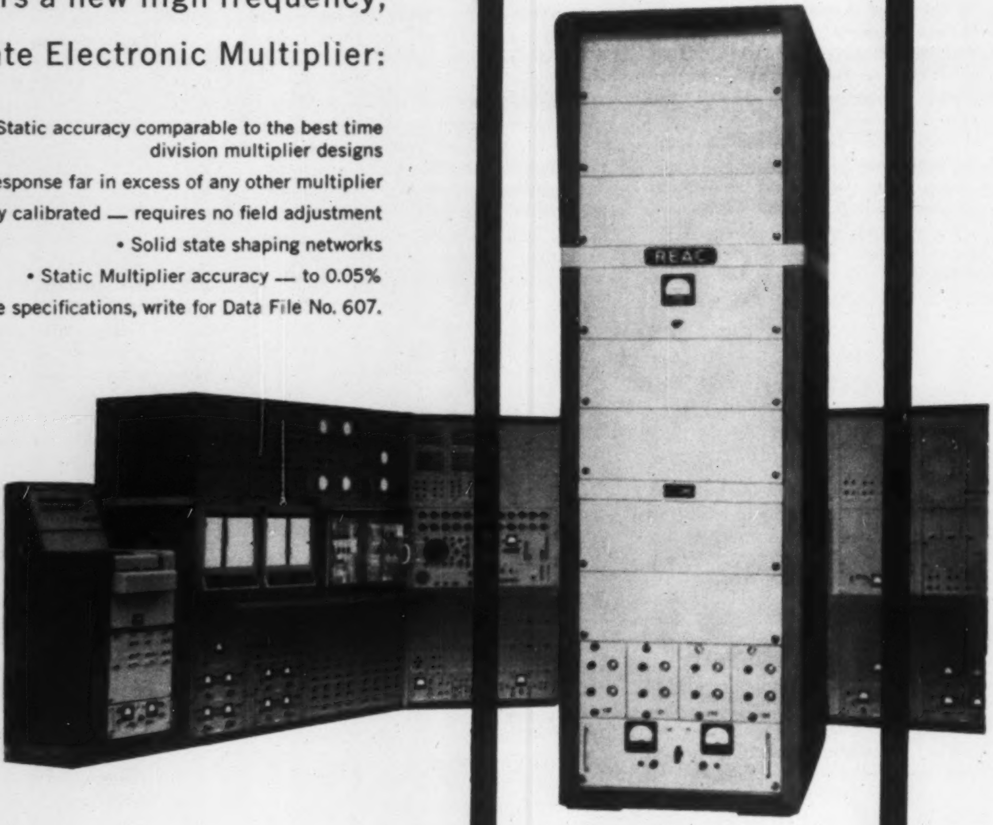

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CIRCLE 52 ON READER-SERVICE CARD

SOUTHEASTERN S/C MEETING OF 15 JAN. ON NYQUIST AND Z-TRANSFORMS

We don't have much info on the Southeastern Simulation Council meeting held at Georgia Tech last January 15th but *Ray Lawrence* (Army Ballistic Missile Agency, Huntsville, Ala.) has forwarded "A Note on Plotting Nyquist Diagrams with the Analog Computer" by *R. S. Johnson* (Georgia Tech), and "Application of the Z-Transform in the Simulation of Sampled-Data Control Systems"* by *Norman C. Seiler* (Sperry, Clearwater, Fla.).

We give you herewith the "Note—a digest of the paper presented by Johnson, but Seiler's 15-pager snowed us. Trouble was, the investigation required a mathematical analysis in addition to the simulation, and this *newsletter* is no place for that!

Johnson on Plotting Nyquist Diagrams With an Analog Computer

The Johnson discussion dealt with the application of the general-purpose analog computer to the computation and recording of complex transfer contours (or Nyquist diagrams) of low-frequency linear networks. Fig. 10 pictures such a network being driven with a reference sinusoid of amplitude E (at some test frequency $\omega/2\pi$) and yielding an output of amplitude A and phase angle θ.

The reference signal and the response are fed into the computing circuitry which computes the quantities ($A\cos\theta$) and ($A\sin\theta$). These computed voltages then are used to drive the X-Y recorder. As the frequency of the reference sine wave is varied, the recorder scribes the required contour.

The technique to be discussed uses the following trigonometric identities as the basis of the computing circuitry:

$$(E\sin\omega t)\,[A\sin(\omega t+\theta)] = \frac{EA}{2}\cos\theta - \frac{EA}{2}\cos(2\omega t+\theta) \quad (1)$$

$$(E\cos\omega t)\,[A\sin(\omega t+\theta)] = \frac{EA}{2}\sin\theta + \frac{EA}{2}\sin(2\omega t+\theta) \quad (2)$$

Interpreting these expressions in terms of the quantities of Fig. 10 we note that the product of the reference signal ($E\sin\omega t$) and the network response voltage yields a d-c term proportional to ($A\cos\theta$) plus a double-frequency term. Similarly, the product of a quadrature reference ($E\cos\omega t$) and the response signal yields a d-c term proportional to ($A\sin\theta$) plus a double-frequency term.

The computing technique is now obvious. As shown in Fig. 11, we generate the two reference signals, form the products indicated in Equations (1) and (2), filter the results to eliminate double-frequency terms, and use the d-c components to drive the X and Y axes of the recorder as we slowly vary the test frequency.

For the lower frequencies (less than 3 or 4 cps) the reference signals can be generated within the computer by an undamped second-order loop. For higher frequencies, an external oscillator seems indicated. In the former case, both the sine and cosine functions are available immediately, whereas the external oscillator requires a phase-shifting network to obtain the quadrature reference ($\cos\omega t$). The phase shifter shown in Fig. 12 has been found satisfactory for this.

A point-by-point Nyquist plot can be obtained by manually adjusting the variable resistance R at each selected test frequency. However, it is not difficult to devise a servo for automatically setting the phase shift as the test frequency is varied continuously. Fig. 13 shows one such mechanism using a servo-driven potentiometer.

The servo-controlled phase shifter is based on the following identity:

$$[E\cos(\omega t+\epsilon)]\,(E\sin\omega t) = \frac{E^2}{2}\,[\sin\epsilon - \sin(2\omega t+\epsilon)]$$

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*Printed, so copies are probably available from the author.

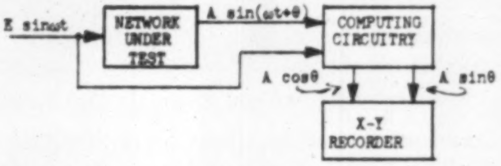


Fig. 10. Basic systems for obtaining sine and cosine functions.

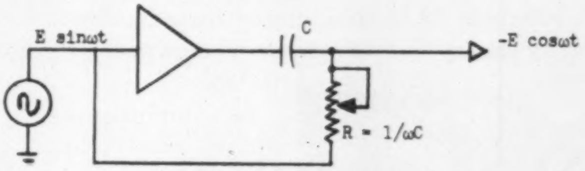
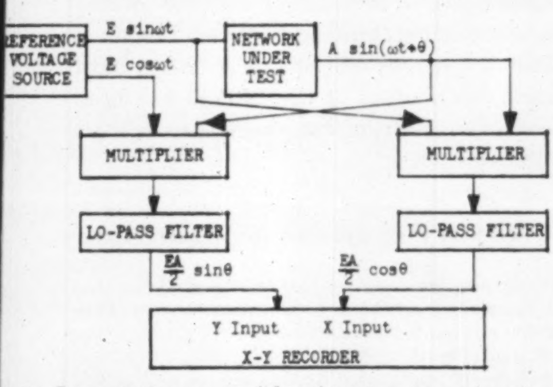


Fig.12. Phase shifter.



. 11. Computation required for obtaining sine and cosine ctions.

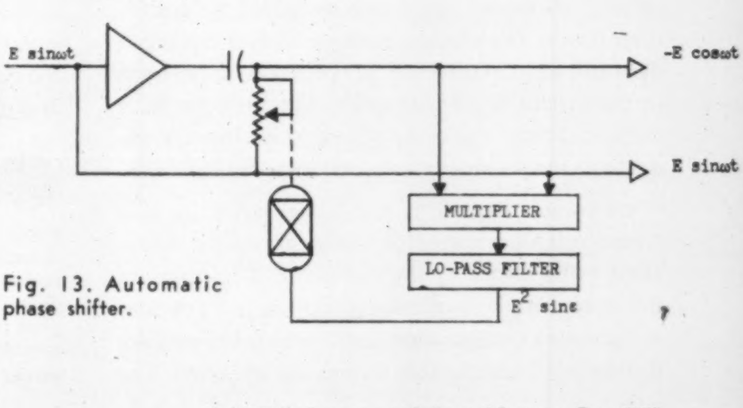


Fig. 13. Automatic phase shifter.

LGP-30 COMPUTER ABSTRACTS

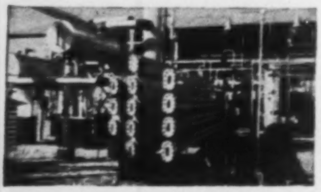
(Application Report #10, from which the following is abstracted, is free upon request from Royal McBee Corporation, Data Processing Division, Port Chester, N. Y.)

Subject: Design / User: Brown Fintube Company, Elyria, Ohio

The Problem: rush quotation for heat exchanger to potential customer. Determine best heat exchanger vs. cost combination. Perform necessary computations to obtain values for total surface area; total number of exchangers; area/exchanger; velocity and pressure drop—shell and tube; film coefficient; log mean temperature difference; overall transfer rate; clean rate; overall fouled rate; surface actually required; duty; price.

Method: the compact, low-cost Royal Precision LGP-30 Electronic Computer.

Input Data: except for special specifications which are handled by design engineers, non-technical personnel fill in data directly from customer inquiry sheets. This information is then punched on tape.



Solution: the engineer reads the above data into storage in specifically assigned memory locations on the computer's magnetic drum. The set of program instructions—also stored on the drum—then directs the computer where to find the input data and what mathematical operations to perform in the proper sequential order. The program then further directs the computer to store the various answers in specifically assigned memory locations.

Of notable interest is the incorporated test feature which allows any type and arrangement of sections to be tested by the computer. The program not only compares calculated values, but provides a corrective computation and recomputes all conditions until satisfactory values are obtained. The engineer need only type in the exact arrangement desired to have the computer calculate his proposed arrangement – assuring complete versatility and control over the program.

Output: all numbers required for the final specification sheet, including price, are provided – as well as key intermediate answers to enable the engineer to exercise judgment. The computer automatically controls the typewriter so that all answers are printed out in the desired format.

Conclusions: with the LGP-30, Brown Fintube has reduced total time on typical heat exchanger designs from one or two hours to approximately 3 minutes. Better design vs. cost combinations have been obtained – with a resulting increase in contract awards and the elimination of under-bidding. According to company officials, "perhaps the most significant contribution of the LGP-30 has been the release of engineering manpower for more basic and profound studies."

Royal Precision Corporation

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. LGP-30 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing offices. For your free copy of Application Report #10, as well as full specifications on the compact, mobile LGP-30, write today to **ROYAL McBEE CORPORATION,** data processing division, Port Chester, N.Y.

CIRCLE 53 ON READER-SERVICE CARD

A phase error, ε, causes a d-c term to appear at the output of the multiplier. The low-pass filter removes the double-frequency component and the residual error voltage drives the servo motor.

Figs. 14, 15 and 16 show three simple contours plotted for demonstration.* In Fig. 14, an undamped second-order loop was used to generate the reference signals and the contour was plotted point by point. Errors at the higher frequencies are caused mainly by amplitude drift of the references.

The contour of Fig. 15 was obtained using a point-by-point method with an external oscillator and a manually positioned phase shifter. Accuracy here is on the order of 1%.

Fig. 16 illustrates the use of an external oscillator with a servo-positioned phase shifter to obtain a continuous plot of the contour. Ripple at the lower frequencies is caused by the phase shifter as the corner frequency of the low-pass filter is approached.

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*These figures were taken from experimental results obtained by R. B. Andreen in connection with graduate studies at Georgia Tech during Summer 1958.

Fig. 14

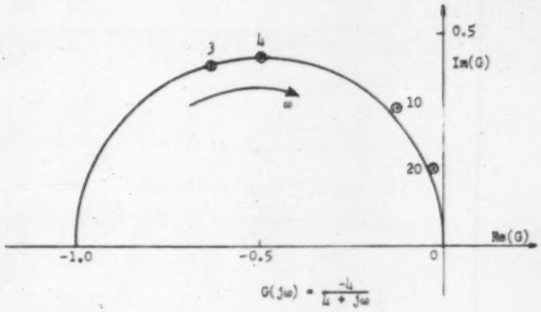


Fig. 15

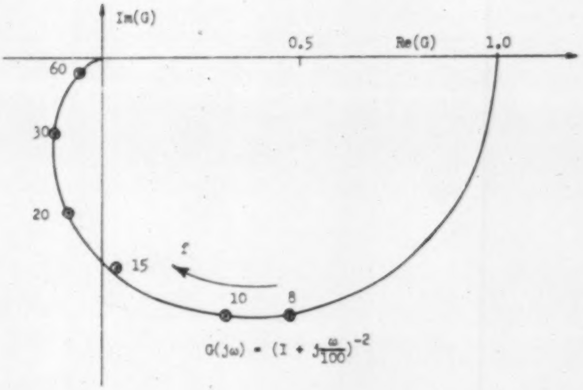
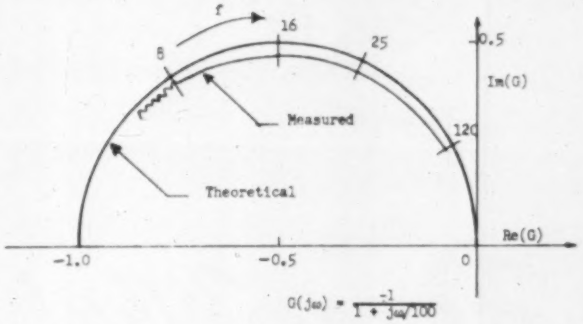


Fig. 16



Calendar of Computer Events

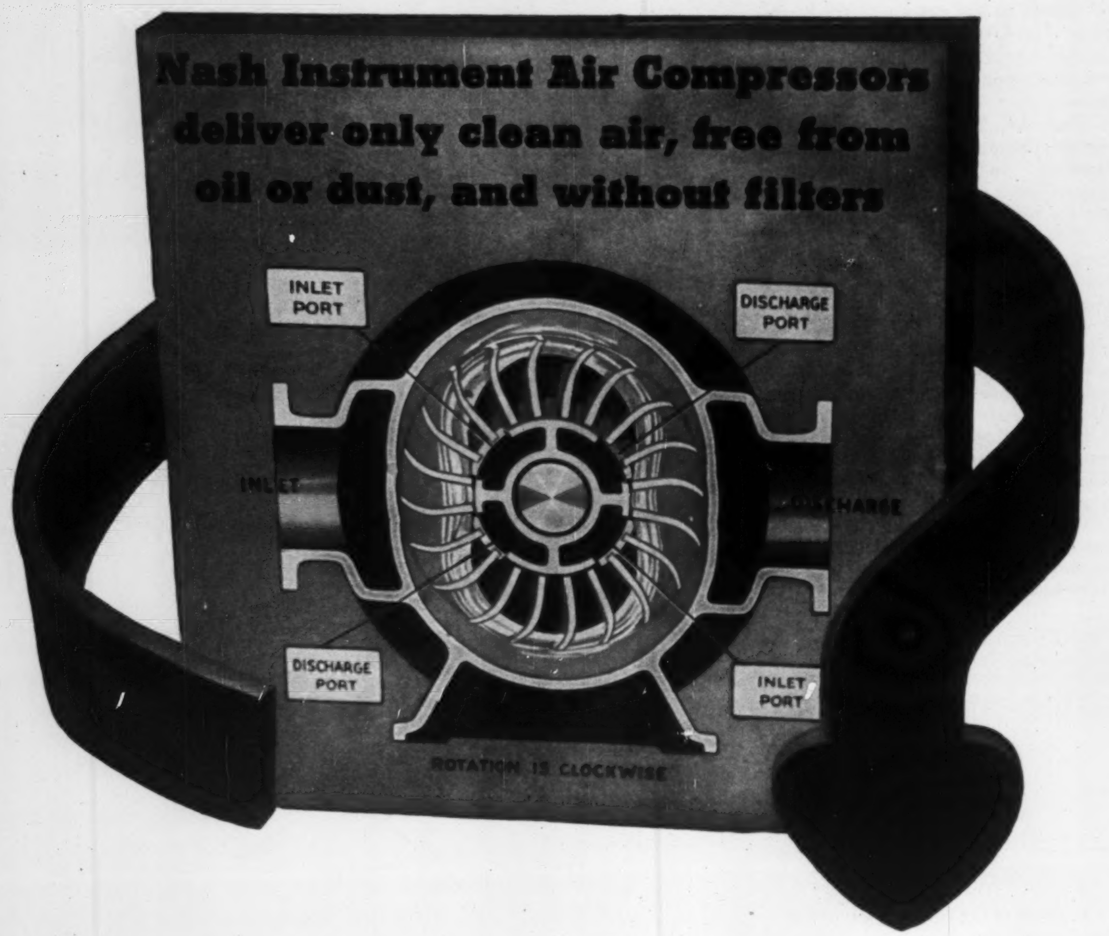
AIEE Pacific General Meeting
El Cortez Hotel
San Diego, Calif.
August 8-12, 1960

AIEE-AIChE-IRE-ISA-ASME Joint Automatic Control Conference
Kresge Auditorium
Massachusetts Institute of Technology
Cambridge, Mass.
Sept. 6-9, 1960

AIEE Power Industry Computer Application Conference
Chase Hotel
St. Louis, Mo.
November 9-11, 1960
(Final date for †Technical Papers—Aug. 11, ‡Conference Papers (Not Published) Syn.—Aug. 26, CPMs—Sept. 5)

AIEE-IRE-ACM Eastern Joint Computer Conference
Hotel New Yorker
New York, N. Y.
December 11-14, 1960
(Final date for †TP—Sept. 12, ‡CP Syn.—Sept. 27, CPMs—Oct. 7)

"OK-OK-I'll LET YOU SPEAK TO THE BRAINS OF THE OUTFIT!"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®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

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Teletype Model 28 punched tape units

The Teletype Model 28 tape reader and typing tape punch combine proved dependability of operation with a variety of features which help streamline data communications systems and save the time of attendant personnel.

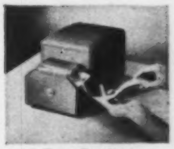
- *Convenience.* On the Model 28 tape reader, a single 3-position start-stop lever controls "on," "off," and "freewheeling." A specially designed tape lid, conveniently hinged, will accommodate either chadless tape or fully perforated tape, without intermediate adjustment.

The Model 28 tape punch not only perforates intelligence into tape—it simultaneously "prints out" the data right on the tape, thus greatly facilitating handling and storage.

- *Low Maintenance.* Both units are designed for extremely low maintenance, with all-metal clutches that require oiling only once or twice a year, depending on usage.

- *Reliability.* Teletype tape equipment is the product of extensive research and precision manufacturing facilities. It is made for continuous, day-in, day-out service with minimum upkeep. Teletype Corporation manufactures this equipment for the Bell System and others who require the utmost reliability from their data communications systems.

Typing Tape Punch



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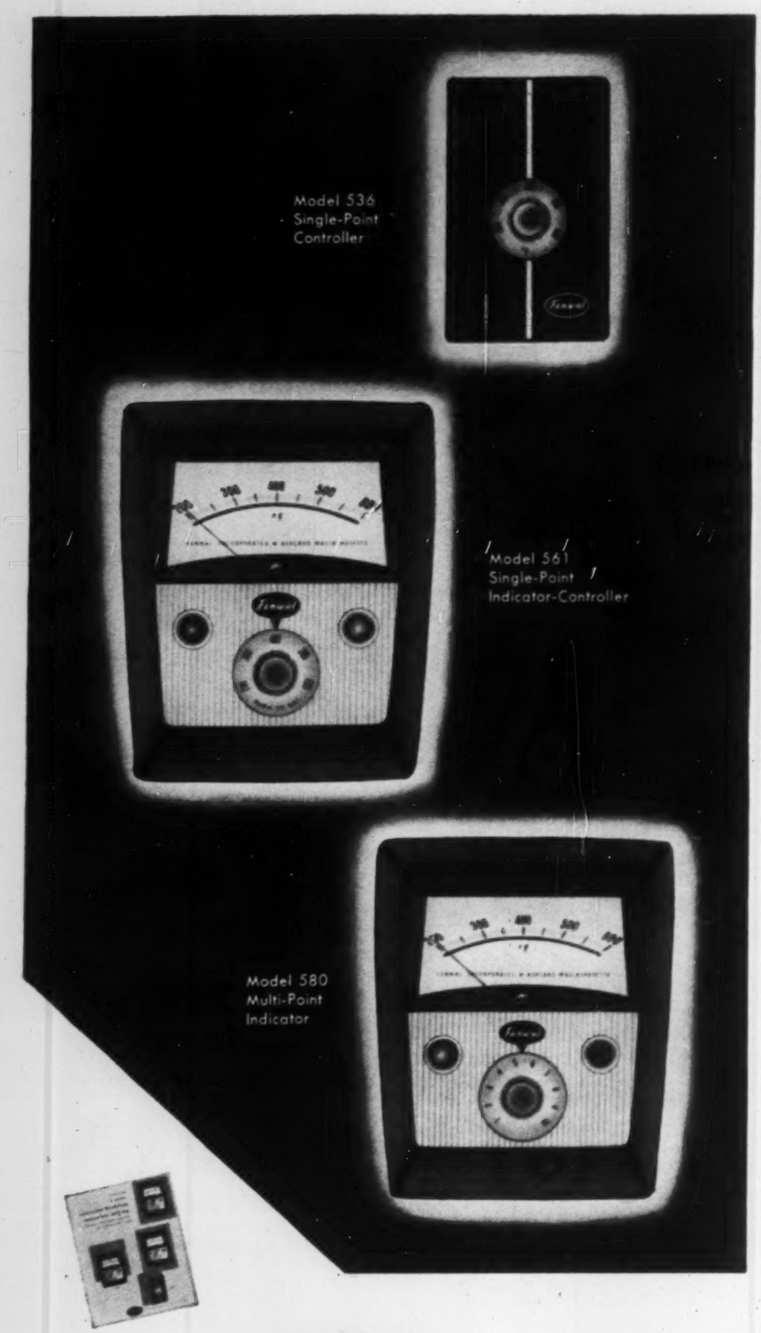

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The Model 536: reliable, single-point controller gives you these options: ON-OFF or proportioning control . . . set-point adjustment in the instrument or remotely located . . . indication as well as control . . . expanded scales for fine temperature adjustment. And you pay only for the option you need. Capacity of 10 amp/110 VAC and 5 amp at 230 VAC.

The Model 561: single point indicator-controller designed for panel mounting. Panel button permits meter display of temperature set point. Control and indication circuits are independent. Mirror-backed scale prevents parallax, tilted glass cover reduces reflection. Option of either ON-OFF or proportioning control. 10 amp/110 VAC relay capacity . . . insensitive to voltage fluctuations.

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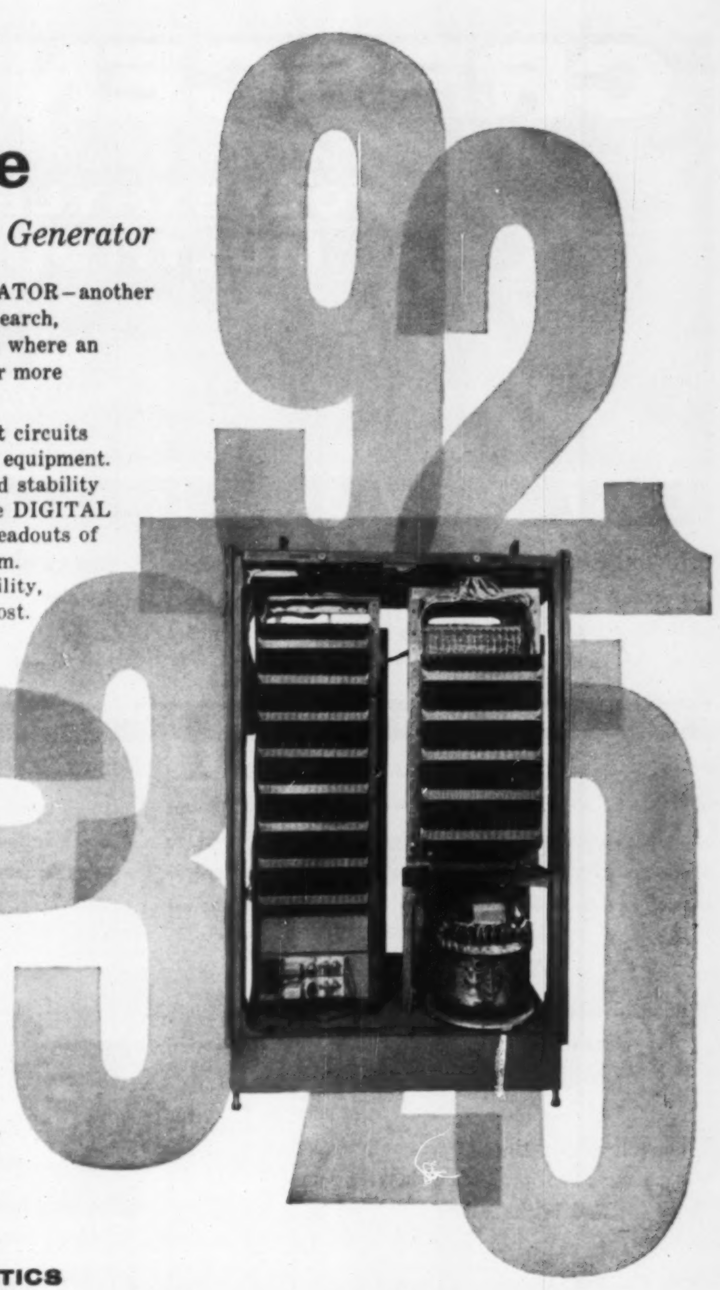

GENERAL SPECIFICATIONS

Computer type:	Special purpose serial digital
Number base:	Binary
Mode of operation:	Parallel
Memory type:	Magnetic Drum
Drum speed:	3,000 RPM
Memory capacity:	330,000 bits on 80 tracks
Word length:	32 bits
Interpolation rate:	800 per second simultaneous computation of division and multiplication
Function generation:	One variable: 0.02 sec/point Three variables: 0.1 sec/point
Accuracy:	0.1% dependent on programming accuracy

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Input: (Continuous electrical analog signal)

Number of inputs:	64 (expandable)
Sequence:	By computer command
Level:	0 to +100 volt
Conversion time:	936 microseconds

Output:	**ANALOG**
Number of outputs:	80 (expandable)
Selections:	Fixed or by mode switch
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Signal:	12 binary bits at a frequency of 204.8 kilocycles per second
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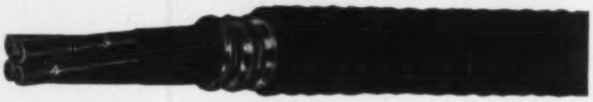
TYPE PA—Interlocked metallic armor provides complete mechanical protection to the inherently corrosion resistant tubing.

TYPE PAT—Polyvinyl chloride sheath over the armor adds corrosion protection for the armor. Can be buried in the earth.



TYPE PT—PVC sheath gives limited mechanical protection. For use in troughs, trays or conduit.

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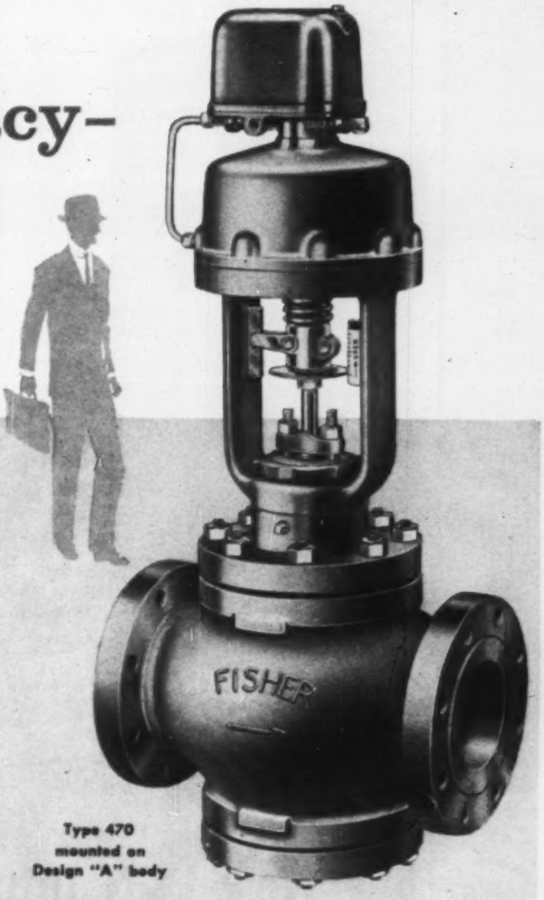
FOR Inherent Accuracy–Power–Speed and Stability

FISHER TYPE 470 P.O.P.



Type 470 mounted on Design "A" body

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- **Adaptable to virtually all types of valve bodies including Butterfly valves.**
- **No air set required—utilizes clean, non-corrosive air or gas up to 150 psi.**
- **Easily reversible actuator can be changed in the field.**

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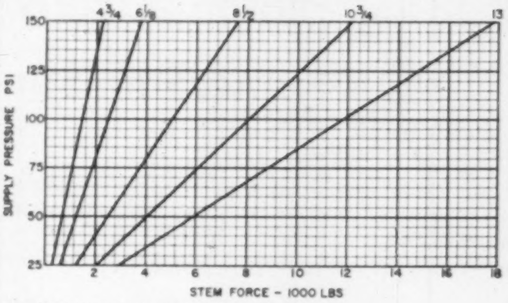
PERFORMANCE DATA

Air Consumption (Static)	20 SCFH at 100 psi supply.
Instrument Signals	3 to 15 psi, 5 to 25 psi, 6 to 30 psi, 12 to 60 psi. Suitable for split range also.
Temperature Limitation	175°F.
Maximum Hysteresis	0.15% of total stroke or instrument signal.
Repeatability	0.03% of the total stroke or instrument signal.
Resolution Sensitivity	Minimum change in the measured variable to produce an effective movement of the final control element is .02% of the instrument pressure range.
Frequency Response	1.4 cps for the Size 60. 4 cps for the Size 30.
Load Sensitivity	Percent of total travel per 100 lbs. stem force is .065% for Size 60.



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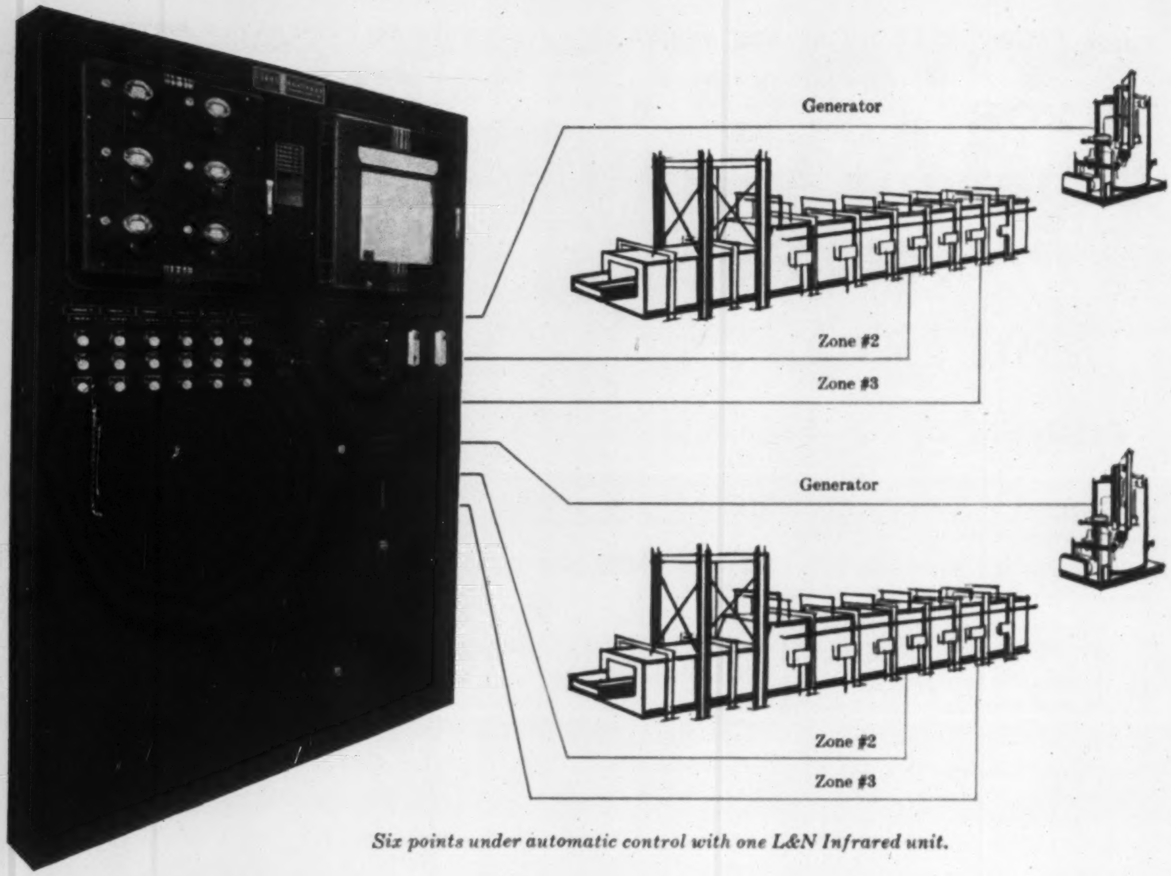

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The L&N IR Analyzer equipment for automatic control of heat treating atmospheres offers five outstanding advantages.

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EDITORIAL

Are We Short in Instrumentation?

E. CARTOTTO, North American Aviation, Inc.

A RAPIDLY EXPANDING PROFESSION feels keenly the pains of its deficiencies. Instrumentation is growing at a phenomenal rate, but it leaves behind many unsolved problems, evidence that we are short in instrumentation—short in training and skills, short in numbers, short in advanced techniques and equipment, short in recognition and status. The instrument user has found new problems faster than he and the instrument manufacturer combined could find solutions.

Increased Accuracy

In most fields the liberal 1% originally acceptable for critical measurements is now useful only for rough evaluations. Requests to achieve 0.25% or 0.2% accuracy for measurements are now common, and trends toward 0.1% are developing rapidly. Laboratory measurements in this realm are customary; however, the rocket- or industrial-test facility does not afford the ideal environment for such accuracy.

The difficulty of achieving these accuracies will be appreciated if we consider the transducer alone. Installed on or near the rocket engine or industrial plant, the transducer experiences the full fury of the environment—severely shaken by structural and airborne vibration, scorched by radiated and conducted heat, frosted by sub-zero liquids, even flooded by fire-fighting deluge. With these handicaps the instrumentation engineer must fight to achieve 0.25%.

The manufacturer has done well, but much more is needed. Many transducers generate spurious signals because of vibration. Temperature gradients across transducers often introduce false information. Even when gradients are not present, operating temperatures drastically different from the calibrating temperature can introduce large errors. Yet the last increment of system performance is attainable only when measurement accuracies and precisions permit every vagary of behavior to be identified, isolated and corrected. Small gains for such great efforts? Not at all; these gains are the difference between mediocrity and superiority.

Beyond the scope of equipment capability lies the problem of requirement determination. Whenever the ultimate in accuracy is required, it must be achieved; when it is unnecessary, it must not be demanded.

Pressing Needs

Although advancements are needed in many areas of instrumentation, there are a few where the need is pressing. Measurement of *low temperature* is difficult because transducers frequently display poor mechanical integrity under test conditions; wire resistance thermometers fail because of material limitations and generally lack response; thermistor thermometers ultimately fail by fracturing; turbine flowmeters, used extensively in rocket testing, need improvement in long-term precision. For conventional fluids as well as for liquefied gases, there is great need for flowmeters not affected by feed system configuration. Also, the problem of mass flow measurement has not been satisfactorily solved.

A second area requiring concentrated effort to achieve advancement is the *measurement of dynamic phenomena*. Systems of greater bandwidth, greater dynamic range, and greater accuracy are needed.

Accelerometers must show less transverse axis sensitivity, greater temperature stability, and better hermetic sealing. Low-noise coaxial cable must be improved and their capability of withstanding high flash temperatures increased.

Measurement of dynamic *stress* phenomena is becoming more important. Critical requirements exist in using strain gages at extreme temperatures. While much work has been done in this field, a great deal is needed. Gage systems showing greater sensitivity at low stress levels are required. Improved bonding agents are needed.

Reliability

Achieving reliability is as difficult as achieving accuracy. The same environment that hampers accuracy works to produce malfunctions and outright failures. Improved reliability gained at the expense of measurement capability is false progress. Compromise of this kind must be avoided, yet reliability must be improved.

Reliability must extend through the data processing methods and systems. This seems best accomplished by the elimination of manual operations. In the past five years several digital data acquisition systems have been developed that accumulate and transfer test data to computers for calculations with a minimum of manual operation.

Until such time as digital processing systems are capable of handling measurements of dynamic phenomena changing at frequencies up to twenty thousand cycles per second, much data will be recorded on magnetic tape in analog form. Reduction of such data for calculations or graphic display is still a slow and tedious process. Octave, panoramic, and spectral-density analyzers have all aided in advancing the art, and some work is being done to develop analog-to-digital techniques capable of handling the high-frequency data. Considerable effort still is required in this field.

Standards

If the accuracies cited are to be achieved, considerable improvement is needed in standards. The controlled laboratory environment seldom exists on test stands during calibration of measuring systems. This unquestionably places an extra burden upon standards and personnel using them.

The best standards available are located at the National Bureau of Standards. Means for bringing this best standard to the test stand are necessary. Though difficult, this is not unrealistic because some such standards currently exist. In the field of temperature measurements, for example, we have the melting point of ice, the boiling point of water and the boiling point of liquid oxygen, all of which can be taken directly to the test stand. Other standards as basic as these are needed.

Statistics

Faced with reviewing and analyzing large masses of data, the engineer is frequently overwhelmed. Statistical techniques are the answer. Unfortunately, the engineer is seldom trained in the field and the statistician is not trusted by the engineer. These deficiencies must be overcome. Contemporary scientists like Simon, Romig, Lusser and Fisher are demonstrating in the literature the validity and power of statistical methods.

Our colleges should excite the student's interest in statistics, in measurements, and in instrumentation.

Report on NBS

A report of a Special Advisory Committee of the National Academy of Sciences on "The Role of the Department of Commerce in Science and Technology."

THE BUREAU'S total full-time staff in June 1959 was 2,960. Some 1,500 were professional scientists or engineers. These were distributed by fields of specialization, as follows: 525 physicists, 300 chemists, 375 engineers, 95 mathematicians, and 175 others. Two hundred seventy-five had obtained their Ph.D. degree, more than one hundred additional had academic training to that level.

The grade with largest percentage of employees has adanced from GS-9 to GS-12. At the same time, average salaries and salaries associated with each grade level have increased. The present average salary of the professional staff is approximately $8,500 per year.

The Bureau of Standards is well administered. The director and his staff have done an outstanding job of managing the limited resources in manpower and facilities to achieve a high level of effectiveness. The staff is of excellent scientific and engineering quality. Within the framework of government employment and compensation policies and practices, a remarkable job of recruitment and building of staff through educational programs and other means has been done.

The development of accurate methods of physical measurement and of standards is of large importance to the commerce and industry of our country. Their needs for standards should be fully met. This the Bureau is not now doing only because of inadequate funds for its operation and for buildings and facilities. Within its resources, the Bureau's performance of its measurement standards function is excellent.

Principal Recommendations

1. The measurement standards effort be expanded to provide adequate coverage of the Nation's standards needs. A rate of increase of effort of about 15% per year is suggested. This rate can be realized without noticeable loss of efficiency.

2. The new facilities now planned for construction at the Gaithersburg, Maryland, site be provided at the earliest time possible.

3. The existing mission statement for Radio Propagation and Standards should be issued as an Executive Order. A similar statement for Data Processing should be prepared, evaluated and, if found appropriate, given similar status.

4. The Secretary should arrange for the establishment of committees of scientists and engineers to review the programs of the Cryogenics Engineering Laboratory, the Hydraulics Laboratory, and the Building Technology Division to determine the scope of the Bureau's responsibilities in these areas.

5. Directly appropriated funds be obtained for all activities in the Measurements and Standards area that are of broad national interest. Transferred funds be employed only for activities of specific interest to the agency providing the funds.

6. The Bureau be given a major increase in number of Public Law 313 positions. Its present request for 45 appears modest.

7. The technical Advisory Committees have a large potential value not yet fully realized. The Director continue his vigorous efforts to bring them to a higher level of effectiveness.

8. The Director critically reiew all of the miscellaneous activities for other agencies such as testing, evaluation of materials and production, and report to the Statutory Advisory Committee the details and results of his analysis.

Two completely new, transistorized, differential Data Amplifiers, Types 491 and 492, by Offner Electronics Inc. Their high precision makes possible an accuracy and simplification of data reduction previously impossible. Sixteen channels of data reduction (Type 492) requires only 8¾" of rack space. Power supply occupies only 5¼". The combination of accuracy, stability, fast response, and size is unmatched.

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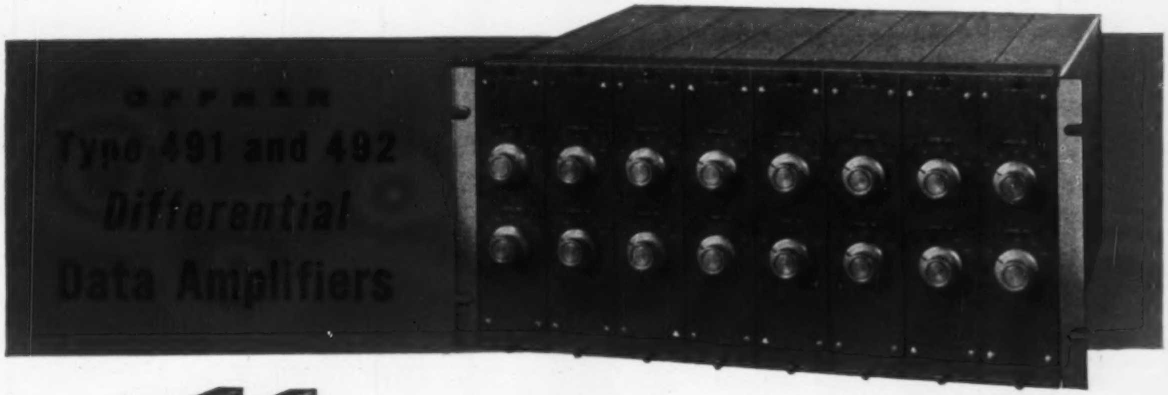

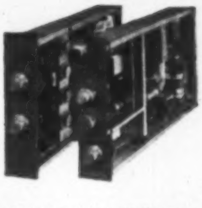

Type 492 Amplifier (left) provides 2 channels of precision amplification per unit. The Type 491 (right) is a single channel unit, with input coupler for added versatility.

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Epsco-West NEWSLETTER

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The biggest single factor is E-W's use of standard data blocks. These functional sub-assemblies, pioneered by Epsco, are field-tested and ready-to-work. Much costly design time is avoided, fewer components are needed.

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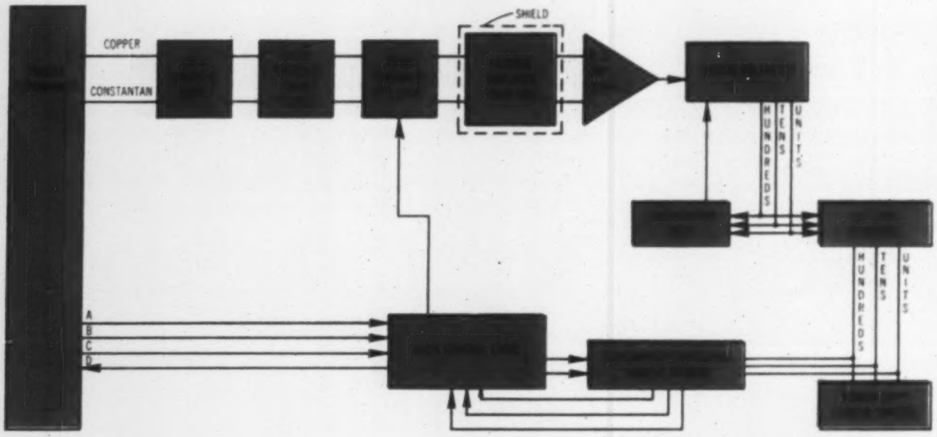
Case in Point–*E-W's novel temperature data logger for a major Northwest nuclear research center makes extensive use of standard building blocks. This low-cost solid-state system continuously monitors and records temperatures at 50 points in a reactor.*



Description–The system consists of a continuity tester, thermocouple bridge with cold junction compensation, low pass filter, differential amplifier, Epsco digital voltmeter, decimal to Flexowriter decoding network, buffer storage unit, and associated logic relay circuitry.

Function–The system will log thermocouple data from nuclear processing, linearize, scale the analog input information and present digital output in "real" quantities.

Overall Accuracy: 0.5%.

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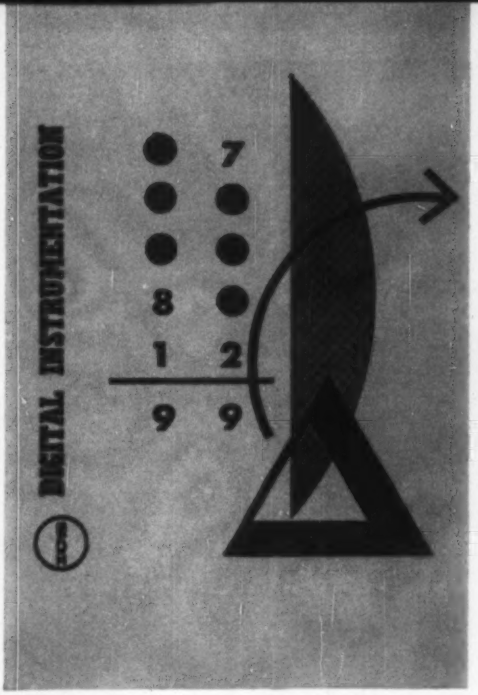

Manipulation of Symbolic-Logic Expressions

ALLAN LYTEL
Crosley Division
AVCO Corporation

The symbolic-logic equation often can be manipulated into a simpler form, saving switches or gates in the implementation.

TABLE 1—TRUTH TABLE FOR LIGHT CONTROLLED BY TWO SWITCHES

X	Y	Light	Condition For Light On
0	0	1	$\overline{X}\cdot\overline{Y}$
0	1	0	
1	1	1	$X\cdot Y$
1	0	0	

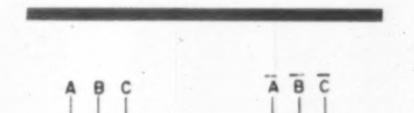

FIG. 1. CIRCUIT in which a light is controlled by two 2-position switches in series.

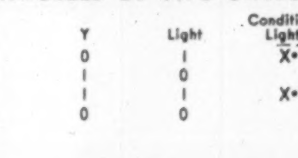
A B C
AvBvC
I
$\overline{\text{AvBvC}}$
$\overline{A}$ $\overline{B}$ $\overline{C}$
$\overline{A}\cdot\overline{B}\cdot\overline{C}$

FIG. 2. DeMORGAN'S Theorem states that the inverse of $A \; v \; B \; v \; C$—that is, $\overline{A \; v \; B \; v \; C}$—is equivalent to $\overline{A}\cdot\overline{B}\cdot\overline{C}$.

THE symbolic-logic equation expresses the operation of a system or a circuit in terms of the basic symbolic-logic operations AND, OR and NOT. It has been shown previously in this series of articles how the equation is developed by use of logic charts, truth tables, or simple statements of fact. It also has been shown how the equation can be implemented by switches and gates.

For example, Fig. 1 shows a light switch that is controlled by two 2-position switches. As each switch can have only two conditions—called 0 or 1—there are only four possibilities, which are shown in the truth table of Table 1.

The symbolic-logic equation for having the light on is:

$$L = \overline{X}\cdot\overline{Y} \vee X\cdot Y$$

It is desirable, of course, to reduce the symbolic-logic equation to its simplest form, in order to implement it most economically. One powerful tool is DeMorgan's Theorem, which states that one can invert a statement by doing the following: (1) change each OR gate into an AND gate, (2) change each AND gate into an OR gate, and (3)

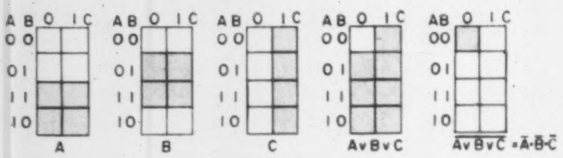

FIG. 3. LOGIC CHART for showing that $\overline{A\ v\ B\ v\ C} = \bar{A}\cdot\bar{B}\cdot\bar{C}$.

invert each term (A, B, etc.). That is, to invert the expression A v B:

$$\overline{A\ v\ B} = \bar{A}\cdot\bar{B}$$

By using DeMorgan's Theorem, all AND gates can be changed into OR gates (or vice versa). For example DeMorgan's Theorem says that the expression (A v B v C) can be inverted as follows:

$$\overline{A\ v\ B\ v\ C} = \bar{A}\cdot\bar{B}\cdot\bar{C}$$

As the inverse of any logic expression is usually readily obtainable, DeMorgan's Theorem becomes a useful method for changing the form of the expression. Fig. 2 shows the implementation of the two logic expressions; one is equivalent to the other, by DeMorgan's Theorem. The proof of this equivalence is also shown in the logic chart of Fig. 3

Redundant Elements

Some logic expressions can be shown to be redundant:

$$X\cdot X = X$$
$$X\ v\ X = X$$

This is shown by the logic chart of Fig. 4.

Another redundant expression is the expression:

$$X\cdot(X\ v\ Y)$$

The logic chart of Fig. 4 shows that this expression is the same as X.

The switch analogy for this is shown in Fig. 5. Note that both X•(X v Y) and X v (X•Y) are equivalent to the simple expression X. In other words, if X is required, then other OR expressions involving X are redundant.

From this it follows that

$$X\cdot(X\ v\ Y\ v\ W) = X$$
$$\text{or } X\cdot(X\ v\ W\ v\ T\ v\ Z) = X$$

Let us consider the expression shown in Fig. 6:

$$X\cdot Y\cdot(X\ v\ Z)\cdot(Y\ v\ X\cdot Z\ v\ W)\cdot T$$

By simple rearrangement of terms, this can be written:

$$X\cdot(X\ v\ Z)\cdot Y\cdot(Y\ v\ X\cdot Z\ v\ W)\cdot T$$

The first two terms are equivalent to X, and the next two terms are equivalent to Y.

Hence this expression (Fig. 6B) reduces to

$$X\cdot Y\cdot T$$

It can be shown that the bridge circuit in Fig. 7 can be cast in any of the forms illustrated.

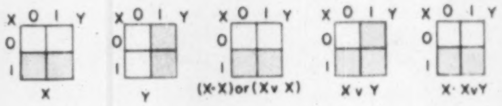

FIG. 4. LOGIC CHART shows that X•X or X *v* X both equal X, and that X•(X *v* Y) also equals X.

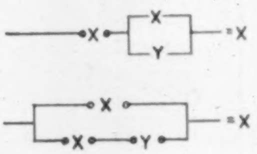

FIG. 5. SWITCH ANALOGY for X•(X *v* Y) and for X *v* (X•Y). Both equal X.

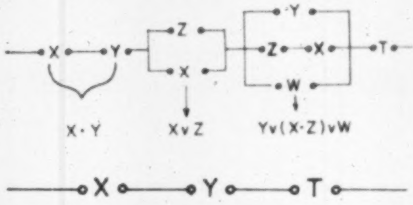

FIG. 6. UPPER circuit is equivalent to lower circuit.

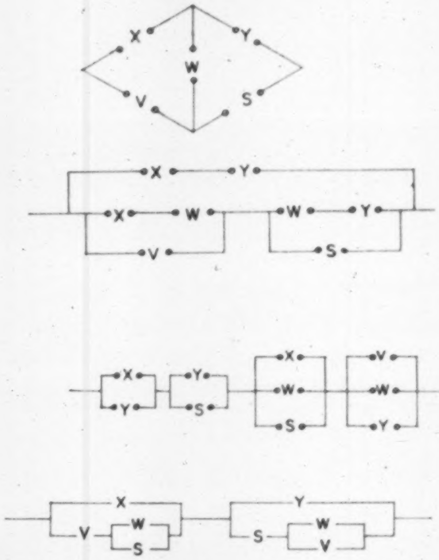

FIG. 7. BRIDGE circuit can be cast in any of the ways shown.

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SM-2 is readily adaptable to data storage and retrieval systems as the on line output device. Typical of this application is LFE's commercially available RASTAD system.

Other applications include air traffic control, intelligence systems, inventory control, production control, process control monitoring, and other applications where information retrieval and display must be simultaneous. Additional specifications available by writing to Dept. 71.

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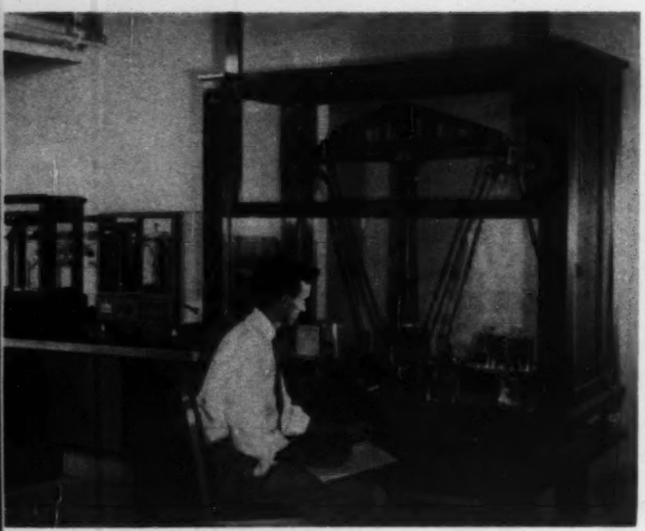


FIG. 1. **STANDARDIZING** test on a 25-lb. weight.

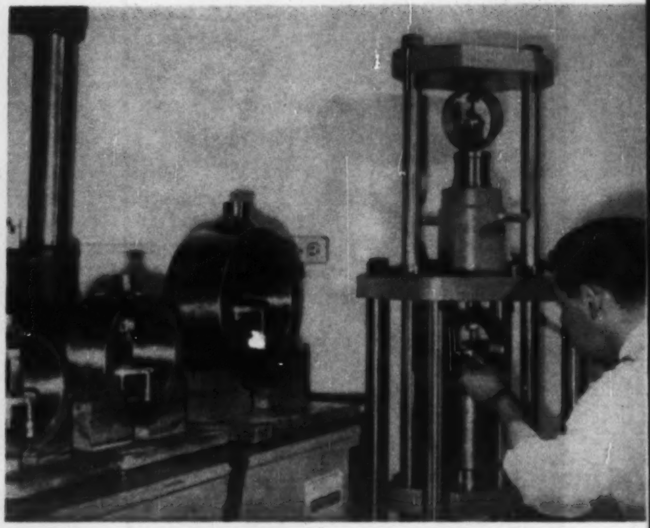


FIG. 2. **COMPARISON** test on a proving ring.

MASS AND FORCE STANDARDS AT GE

S. C. RICHARDSON
General Electric Company

The mass standards at the General Engineering Laboratory of the General Electric Company include reference-level and working-level weights; standards of force comprise five proving rings.

REFERENCE LEVEL standards of mass consist of a set of Class-M rhodium-plated brass standards over the range of 1 milligram to 100 grams, and a set of Class-S stainless standards over the range of 100 grams to 25 kilograms. The *working standards* consist of a set of stainless-steel Class S weights that cover the range of 1 milligram to 1 kilogram and a number of Class-C avoirdupois weights at the 1-, 2- and 25-lb values.

To complement the mass standards, there are four equal-arm balances (Fig. 1) that have capacities of 20, 200 and 1000 grams, and 25 kilograms. These standards are used for the testing and certification of other sets of weights in either analytical or larger denominations. They also are used for (1) accurate weighing of bearings, stills, or other items in which change of weight is of engineering importance, (2) volumetric standardization using distilled water at a known temperature, and (3) determination of specific gravity of both solids and liquids.

Force

Reference standards of force consists of a set of five proving rings. They are used to test and certify physical testing machines to ASTM specifications, hardness testers, and other special force measurements. These proving rings have capacities of 1,000, 2,000, 10,000 50,000 and 200,000 lbs. They are tested and certified annually by NBS. Forces below 100 lb are obtained by using the Class-C avoirdupois weights.

Abstracts from ISA Preprint 9-59.

Developments in Weighing

A summary of recent developments and advanced techniques in weighing.

Wm. Ainsworth & Sons

A *vacuum automatic recording balance* (Fig. 1) will weigh samples in air or inert gas, at atmospheric or reduced pressure, at room or elevated temperature. The recorder chart shows actual or differential weight, instantaneous weight and rate of change. The balance mechanism is the symmetrical-beam type. The beam is 5" long and has a magnetic damper. The deflection of the beam is detected by a variable-inductance transducer in a bridge circuit. Any imbalance in the bridge circuit gives a signal which is amplified to operate the recorder and so balance the bridge. Whenever the recorder pen approaches either edge of the chart, a weight is automatically added or subtracted, as required. This moves the beam and the pen to the other end of their ranges, ready for another sweep across the chart. There are enough combinations of the switch weights (programmed by the cams) to do this 39 times, giving a completely automatic range of 40 ten-inch chart widths. The weight recording is linear and accurate over the entire range. The switch weights can be operated manually or by the switch on the base frame for set-up work.

Tares with density similar to the sample can be used, so that the effect of changes in air buoyancy caused by evacuation of the system may be minimized. Balance capacity can be 200 g, or 100 g. One division on chart (1/10") is 1 mg, or 0.1 mg. Over-all weighing accuracy within automatic range is ±0.2 mg for the analytical balance, +0.03 mg for the semi-micro balance.

C. A. Brinkmann & Co., Inc.

Brinkmann offers the Sartorius line of balances.

The Sartorius *Kilomat* (Fig. 2) is an automatic balance for weighings up to 3000 grams (3 kg). No manipulation of weights is necessary for sample weights up to 1000 grams. Above this range weights are removed mechanically by lever handle to compensate for the excess of weight on the pan.

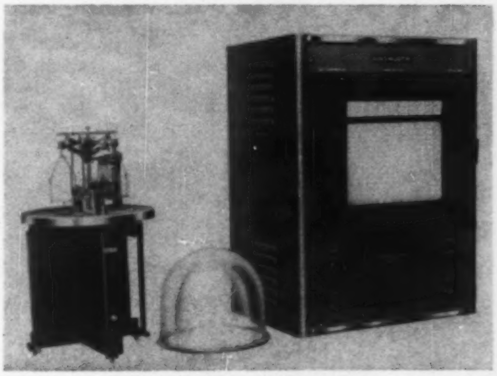


FIG. 1. AINSWORTH recording balance has environmental chamber.

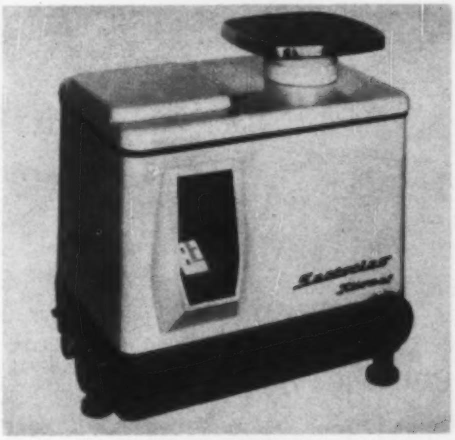


FIG. 2. SARTORIUS Kilomat features automatic manipulation of weight.

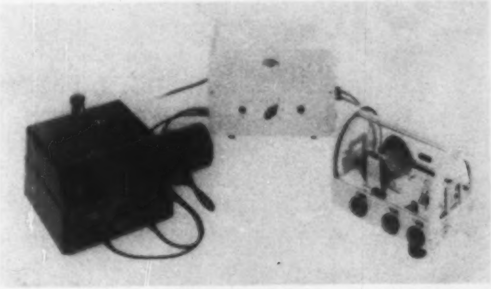


FIG. 3. SARTORIUS Micro-balance, with sensitivity of 1 microgram, has electronic circuit that develops balancing torque.

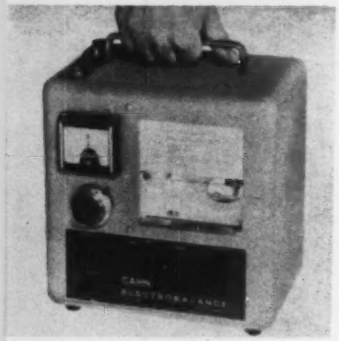


FIG. 4. CAHN Electrobalance.

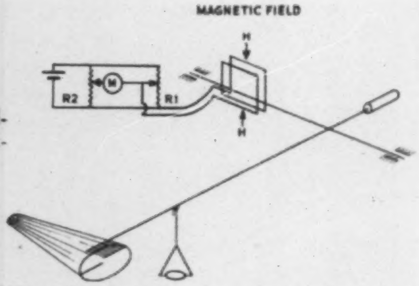


FIG. 5. PRINCIPLE of Electrobalance.

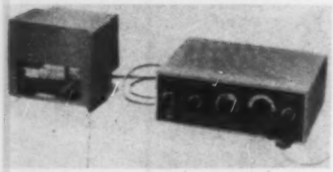
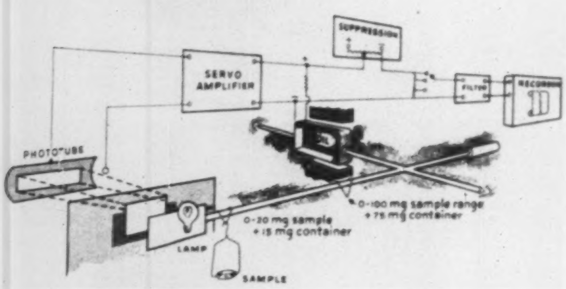


FIG. 6. CAHN automatic Electrobalance and principle.



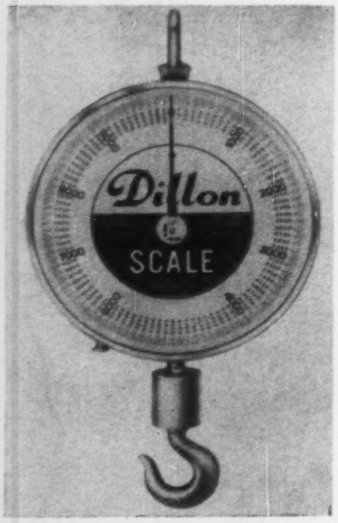


FIG. 7. DILLON Model P scale.

Individual microweighings and continuous automatic registration of minute changes in weight or force can be made with the Sartorius Electrona micro balance (Fig. 3).

Capacity is 1 gram. Maximum sensitivity per scale division is 1 microgram. Eight weight ranges can be provided from 0-100 micrograms to 0-20 mg.

In the Electrona a change of weight produces a torque moment. In ordinary torsion balances this would cause the beam to change its position. This movement is inhibited electronically by a current whose flow, after equilibrium is automatically established in the bridge circuit, is proportional to the change in weight. Beam oscillation is stopped by an incidental damping effect of the compensating current. The result can be read on the indicating instrument or can be recorded. Recorder or indicating instrument should have a range of approximately 0-10 mv. Over-all accuracy is 0.05% of range, but not better than 1 microgram.

Brinkmann also offers Selecta balances which use the variable-load principle.

Cahn Instrument Co.

The Cahn Electrobalance (Fig. 4) uses the principle of Fig. 5. Current through the coil applies a torque to the beam. Coil current is adjusted by means of R1 to make the torque equal and opposite to that developed by the sample. Alignment of the beam is indicated by a fiduciary mark. Coil voltage is measured accurately with a precision potentiometer R2 and galvanometer M. Auxiliary circuits compensate for variations in pan weight, battery voltage, etc., and calibrate multiturn dial R2 so it reads directly in micrograms.

As the beam is always returned to the same position, torque is exactly proportional to current, in accordance with Ampere's Law. As the balance is calibrated with a known mass, measurements are in true mass units independent of the local force of gravity.

The RM Automatic Electrobalance (Fig. 6) operates similarly and provides continuous and automatic balancing of the sample with an electromagnetic torque, providing a voltage output exactly proportional to sample weight. Max sensitivity is 1 microgram.

Any change in sample weight causes the beam to move, momentarily. Beam motion causes a change in phototube voltage, which is amplified and then applied to the coil to rebalance the beam. Phototube ensures that the detector cannot exert any force on the beam itself. The coil torque motor is linear and reliable. Its null-balance principle makes the RM essentially independent of variations in tube characteristics and other circuit components. Time constant is 0.1 second; 0.02 second if needed. Any potentiometric recorder with 0.5-megohm input impedance can be used.

W. C. Dillon & Co., Inc.

Dillon has solved the problem of engineering a mechanical leverage system that can handle 10,000 lbs to fit into a 16" diameter housing.

Mechanism of the Dillon Model P Scale (Fig. 7) is based on compound leverage (Fig. 8). By positioning of the fulcrum point, heavy weights are balanced against an opposing force provided by Iso-Elastic springs. Counterload characteristics remain stable regardless of temperature extremes. Cyclic loading life is virtually beyond computation. Sealable accuracy is 0.1% of full-scale capacity (½ of one dial division). A 10,000-lb range is available, using lever ratios of (4:1) (5:1) (5:1) (5:1), for a total of 500 to 1. Thus only 20 lbs are exerted against the temperature-compensated springs at "E".

The Model P is available in ranges from 0-250 to 0-10,000 lbs.

Action of mechanism lock depresses cam at scale center causing it to move against bar and secure all parts solidly. Dash pot is fully adjustable from rear of mechanism case by screwdriver.

The Seal of the Los Angeles County Bureau of Weights and Measures affixed to the face of every Model P Scale assures that the unit meets the acceptance tolerance of the United States Bureau of Standards for sealable scales as set forth in Section T.2.2 of *Handbook* 44.

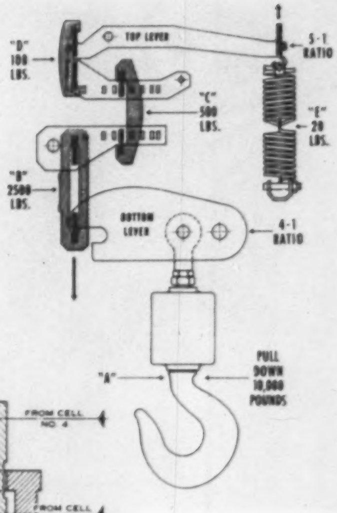


FIG. 8. PRINCIPLE of Model P scales.

A. H. Emery Co.

Emery's WAY-PAC Load Totalizer (Fig. 9) combines the load on two, three or four load cells. The diaphragms accept the load from either two, three or four load cells and transmit this load to a floating force flame. The force flame transmits the combined force to a totalizing diaphgram which converts the combined load to a hydraulic output pressure. This output signal is then used to operate indicating, recording, control or printing equipment.

The load totalizer can be used with either 1,000-pound cells or 5,000-pound cells.

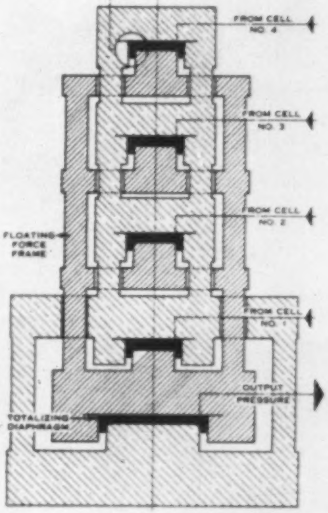


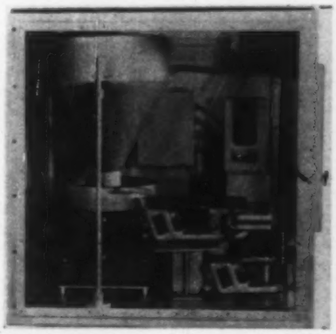
FIG. 9. EMERY Way-Pac load totalizer.

Exact Weight Scale Co.

Case-and-bag checkweigher (Fig. 10) is available with or without rejector mechanism for over- or under-weight products. Controls consist of direct-reading photoelectric cells (mounted adjacent to optical dial) or differential-transformer transducer, depending on requirements. Mechanical scale design uses proven 1-to-1 ratio (equal-arm) lever principle. Optional equipment includes recorders, counters, visible or audible signaling devices and special control accessories.

Model 1206 automatic checkweigher with horizontal (side by side) rejection is designed for weighing tall products, such as cans, cereal cartons, pistons, etc.

Automatic net weighing machines (Fig. 10) are designed for packaging, bagging, batching and compounding, counting tablets by weights, feeding of chemicals, drugs, etc. Features which contribute to high-speed net weighing include minimum distance for material fall, fast-responding lever system, two rates of feed, each fully adjustable, to provide bulk and dribble feeds, and fast weigh-hopper discharge. Operating sequences can be (1) full automatic, (2) push-button fill, automatic dump, (3) automatic fill, push-button dump, or (4) push-button fill and dump.



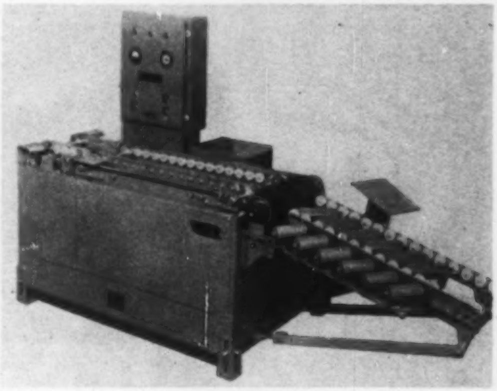


FIG. 10. EXACT WEIGHT bagging and weighing machine (right) and case-and-bag checkweigher (bottom).

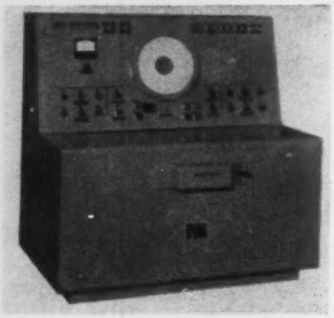


FIG. 11. FAIRBANKS-MORSE program control console for batching up to four materials.

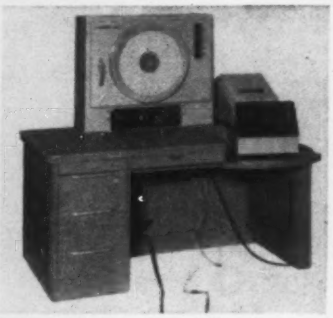


FIG. 12. FAIRBANKS-MORSE Model Q provides automatic ranging, balance, and print out.

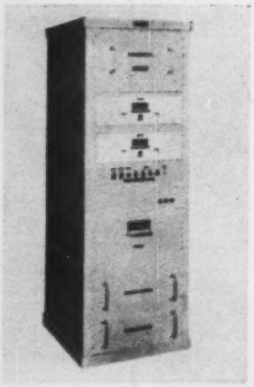


FIG. 13. GILMORE field standard calibration system.

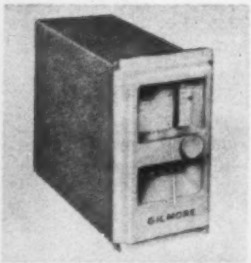


FIG. 14. GILMORE digital indicating and recording system.

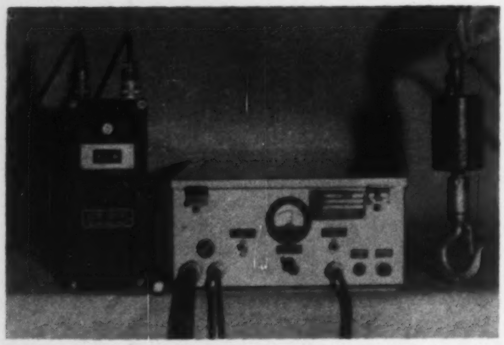


FIG. 15. GILMORE portable load-cell hoist scale.

Fairbanks, Morse & Co.

Fairbanks, Morse Card-Reader Electronic Program Control Console (Fig. 11) is designed for use with strain-gage load cells. It provides batching up to four materials into a formula mix. Prepunched card, containing material selections, weights, and dribble control, is inserted into slot and locked in. Upon pressing the start pushbutton the sequences of material selection, ingredient feed, and control of dribble becomes automatic in operation. When furnished with a mechanical-electrical readout, weights can be printed for use in inventory, scheduling, and associated accounting procedures. Features such as zero tolerance, overload protection, partial batch selector, moisture compensation, batch counters, etc., are optional.

Model Q instrument console (Fig. 12) also is designed for use with strain-gage load cells. Null-balance servo system features high-speed weighing with automatic ranging, balance detection, and print out. Readability is up to 1 part in 10,000.

A standard printer is capable of up to a ten-digit entry in or printing cycle. The printer can be furnished with a keyboard deck for direct entry of data pertinent to the weight transaction.

Ferguson-Hille & Assoc., Inc.

Ferguson-Hille offers hydraulic digital scales based on a force mechanism that develops a force by means of binary-proportioned cylinder sections (cylinder areas are binary proportioned). Cyclic-proportional digital units also are available.

Gilmore Industries, Inc.

Gilmore offers high-accuracy field-calibration units (Fig. 13) for calibrating launching platforms and other load-cell weight facilities. By using specially calibrated and compensated load cells, accuracies of better than 0.05%, verified by the NBS, are possible.

Fig. 14 shows a new Digital Servo Indicator which combines the high accuracy of digital readout with analog recording of weight.

Fig. 15 shows a small mobile battery-operated hoist scale (Model 116) made portable for tractor mounting. Similar units are made for crane installations with optional floor repeaters and recorders. Weight readout can be attached to pendant control for floor-operated hoists.

International Railroads Weighing Corp.

International Railroads has developed a system called "Railweight" which permits weighing freight cars individually while an engine pulls the train at 4 to 7 miles per hour. During tests, individual 150,000-lb cars in a moving train were weighed within an average of 18 pounds (a 350-lb error is allowable under the railroads weight tolerance rules).

"Railweight" is a set of specially designed rails at the approach to a standard scale, which eliminates the bind between car couplers. Heretofore, weighing cars individually while coupled and in motion has been difficult because of the transfer of weight between cars through the bond couplers, which made one car weigh heavy while the other weighed light.

Hagan

Hagan offers a "ham pumping station" (Fig. 16) which automatically controls pickle injection in ham artery pumping, thus eliminating all computations for determining proper pickle injection portions as well as errors in actual weighing. A selector dial indicates percentages of pickle solution based on the weight of each ham. With this dial at the desired setting, the operator only has to insert the injection needle and move a single lever that starts the pumping operation.

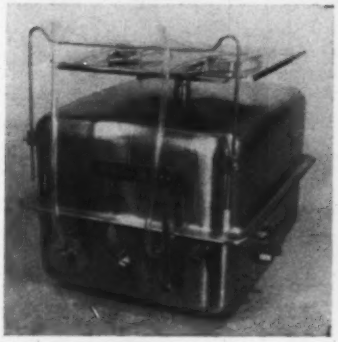


FIG. 16. HAGAN ham pumping station.

Martin-Decker

Martin-Decker offers two recent developments, a remote-indicating crane scale (Fig. 17) and a sheet-lifter with built-in scale (Fig. 18). Both use the Martin-Decker hydraulic load cell described previously.

The remote indicating crane-scale units are available in ranges from 0-1000 lbs to 0-60,000 lbs.

Fig. 18 shows the hydraulic weighing attachment manufactured by Martin-Decker for Cullen-Friestedt Co., which equips their sheet-lifter with a built-in scale. The compression load cell is installed between the head beam of the sheet lifter and a lever. The lever is in turn attached to the crane hook bale so that as material is lifted, the weight is applied to the cell through the lever. The indicator is in a protected position between the arms of the lifter.

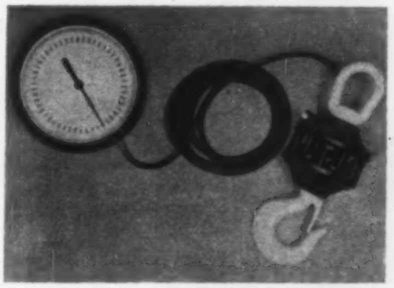


FIG. 17. MARTIN-DECKER remote indicating crane scale.

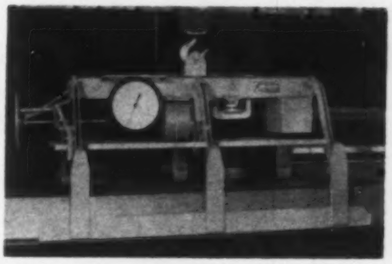


FIG. 18. MARTIN-DECKER sheet lifter with built-in scale.

Mettler Instrument Corp.

Mettler offers recording balances (Fig. 19) to permit continuous recording of changes in weight as a function of time. These balances use the substitution principle. The balance and recorder are connected photo-electrically to avoid feedback. Effective width of the recording chart is 1000-mm (five sections 200-mm width each). Weighing range can be 160 g, or 800 g, with recording accuracy respectively ±1 mg, or ±0.1 g.

Mettler offers also the DWA filling balance (Fig. 20) designed for automatic dispensing of granular or powdered substances. Model DWA-10 has a 10-g capacity and ±20-mg accuracy; Model DWA-100 has a 100-g capacity and ±0.2-g accuracy. Features include automatic sensing and rejection of overweight samples (underweight samples are not possible); automatic alarm when feeder control is out of adjustment or when supply hopper is empty; automatic timing and programming for automatic transport of containers; vibrator feed for most precise control of tolerance.

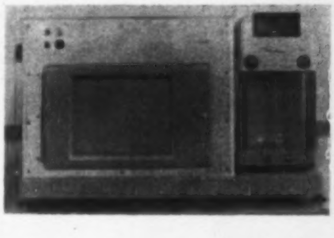


FIG. 19. METTLER recording balance.

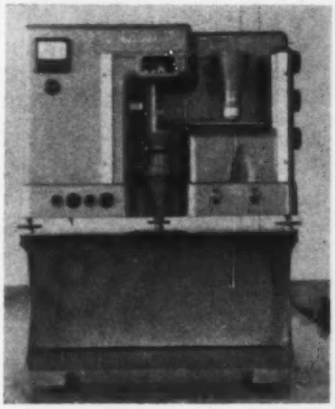


FIG. 20. METTLER DWA filling balance for automatic dispensing.

Microchemical Specialties Co.

Michrochemical offer "Misco" quartz balances for use by microanalyst, biologist, and physical chemist (Fig. 21). Fused quartz is recognized as a nearly ideal material for small scale weighing devices because of its unique properties: (1) elastic range extends to breaking point; no hysteresis, (2) coefficient of expansion is negligible at all ordinary temperatures,

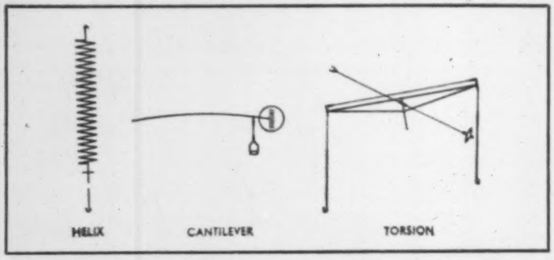
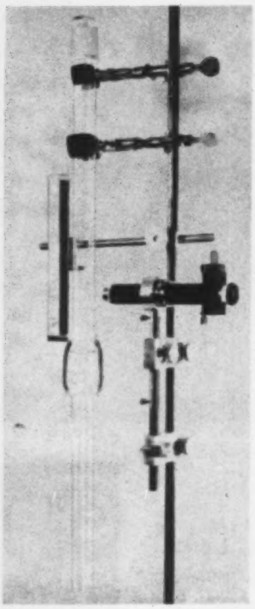
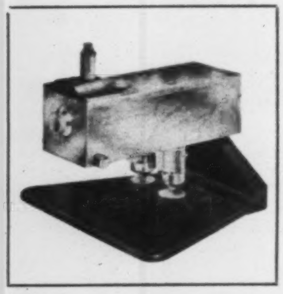


FIG. 21. MISCO quartz balances uses helical, cantilever, or torsion principle (top). Ultra micro torsion unit is shown below.





(3) tensile strength is greater than that of steel, (4) can weigh at high temperature; a furnace can be placed around the balance, (5) operates in any gas, (6) balance may be sterilized and kept sterile during weighing.

The quartz helix balance has sensitivities from 1 mm/200 milligrams to 1 mm/10 micrograms, and load capacities from 20 grams to 2 milligrams. The load capacity of helix balances is determined by the practical length of extension, and the extension per unit weight. Thus, with a practical extension of 20 cm, in a typical housing, a balance which extends 10 mm/1 mg would have a capacity of 20 mg and would detect 0.01 mg (0.05 ug optical reader).

The most important specification for the helix balance is the extension per unit weight.

Salvioni balances depend on the bending of a straight quartz fiber by the sample. By employing a fiber of considerable rigidity, relatively high loads may be carried while the smaller movements produced are measured with a filar micrometer and microscope. The precision micro weighing device is provided in various sensitivities ranging from 1 to 0.1 microgram.

The quartz ultramicro torsion balance is a null-point instrument using the torsion principle with a fine quartz fiber supplying the torque required to return the beam to its original position. Small deflections of the beam are detected by means of an optical system. Accuracy is 0.1 microgram in standard models, up to 0.001 microgram in special order. Load capacity is four million times the sensitivity.

Ohaus Scale Corp.

FIG. 22. OHAUS moisture balance.

The Ohaus Moisture Determination Balance (Fig. 22) is a combination drying unit and precision balance to measure the moisture content of a wide variety of products and materials. It can be used for solids or for liquids and shows the percentage of moisture directly to plus or minus 0.1%. The percentage of moisture loss can be read directly throughout the entire cycle as the moisture is driven off. This feature enables an operator to plot the loss of weight against time. Once this is accomplished on a few representative samples of any given material, the operator can estimate how long a drying cycle should be used. Then repeated tests can be run without the operator's presence, as the balance has a timer with 1-minute settings up to 60 minutes. Upon completion of the run, the balance shuts off automatically.

Ohaus also offers a complete line of precision weights and scales.

Revere Corporation of America

FIG. 23. REVERE force calibrator.

Revere offers C & S Force Calibrators (Fig. 23), with direct-reading accuracies of 1/20 of 1%, and also single-cell weighing kits with direct-reading accuracies of 1/10 of 1%. These are portable, moisture-proof and available in capacities from 5000 to 100,000 pounds. The force calibrators are designed for calibration of physical testing machines, thrust stands and conventional load measuring and weighing devices.

Single-cell weighing kits are used for varied weighing requirements, such as spot checking of loads and forces, as well as for supplementing aircraft weighing kits where an additional support point is required.

The Revere electronic *aircraft weighing kit* is the size of an average man's suitcase and portable. Guaranteed accuracy is 1/10% of the applied load. Models are available in a range of capacities for all sizes of aircraft. A load cell is placed between the axle jack and the jack point. Necessary adapters are standard accessories. Load can be 200% of rated capacity. All weighing kits will operate with either 28 vdc or 110v 60-cycle ac. Capacities range from 30,000 to 400,000-lb aircraft.

Revere also offers the Cox & Stevens line of load cells.

August Sauter

Sauter's "Manopan" (Fig. 24) uses substitution weighing and has a range to 200 g. Values below 110 mg, and differentials smaller than 110 mg, are read on the projection scale, which shows vernier beam angle. Weights are manipulated by external controls. Tare can be up to 30 g. Readability is to 1/20 mg.

Schelm Industries

Schelm Industries has developed a portable electronic scale especially for on-the-job use in the field to give a positive evaluation of earthmoving equipment performance (Fig. 25). The scale consists of four load links, a weight bridge and a digital readout unit. The entire unit is carried beneath a specially designed highway trailer which makes transporting simple. The scale weighs an entire axle at once; normal axle weighing time is ten seconds. Load capacity is 120,000 pounds; load links have an accuracy of ±0.5% with a repeatability of ±0.5%.

Torsion Balance Company

This firm offers a line of balances using the torsion of a taut band as the restoring force (Fig. 26). By means of adjustable poise weight, the center of gravity of the balance is accurately positioned above the center of rotation. The position of the center of gravity determines the sensitivity of the balance. When inequality of weight is established in the two pans, the beam tips in the direction of the greater weight. The force of gravity always acts in a direction opposite to the torsional resistance of the bands. The action of the balance as it oscillates is limited to the slight torsional twist of the taut torsion bands. There is no friction. Most sensitive unit available has a sensibility reciprocal (1 division motion) of 6 mg. Because of the absence of wear, once the balance is in adjustment it remains so as long as it functions.

Wallace & Tiernan Inc.

The Merchen Pneumatic Scale Feeder (Fig. 27) is a continuous weigher which controls the flow of dry, free flowing materials in accordance with a manually-set pneumatic signal, or in proportion to an automatic pneumatic signal from an external source.

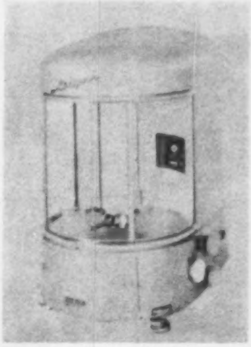


FIG. 24. SAUTER'S analytical balance presents readout directly behind sample pan.

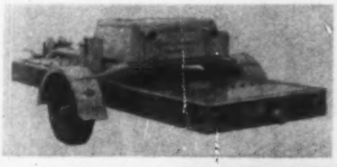


FIG. 25. SCHELM field scale for earth-moving equipment.

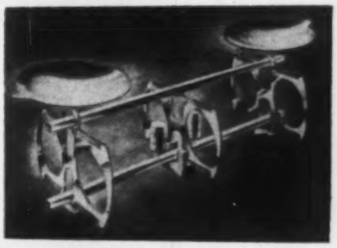


FIG. 26. TORSION balance element.

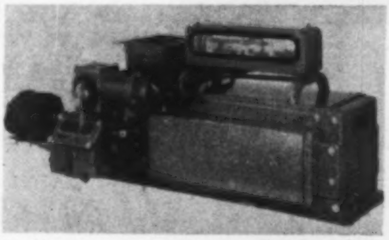


FIG. 27. W&T pneumatic scale feeder.

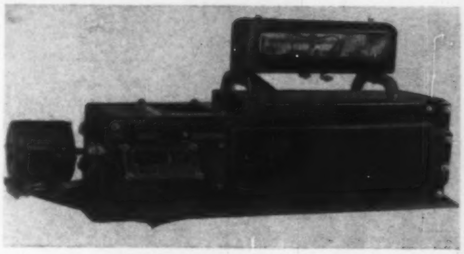


FIG. 28. W&T scale meter.

The scale is a pneumatic force-balance system which develops a pneumatic signal that is directly proportional to the rate at which material is delivered by the feeder.

Accurate continuous weighing of free-flowing solid materials is the function of the Merchen Scale Meter (Fig. 28). A graphic record of the rate of flow and a continuous totalization of the weight of material handled are provided.

The scale is the weigh-belt type where the material is carried over a sensitive scale by a continuous flexible belt.

Load-Cell Weighing

LARRY S. WINSTON

Gilmore Industries, Inc.

FIG. 1. WEIGHING ingots in terms of loss-of-weight of pouring ladle. Flow of molten metal is automatically stopped after predetermined amount is poured.

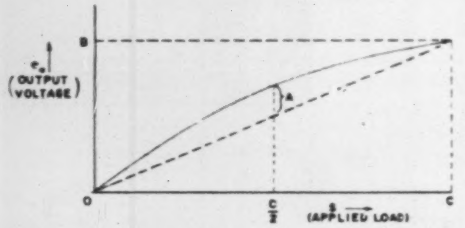


FIG. 2. LOAD-CELL characteristic is nonlinear. Maximum deviation from linearity is 0.1%.

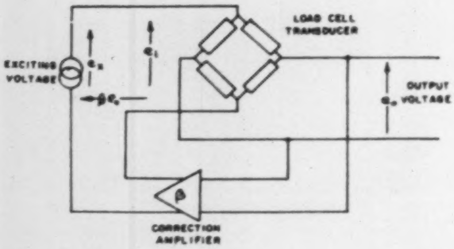


FIG. 3. COMPENSATION for one load-cell (with four strain gages) by means of feedback.

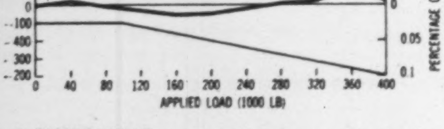


FIG. 4. WEIGHING system accuracy as determined by actual tests.

IN LOAD-CELL-TYPE WEIGHING systems, the load-cell itself is generally the accuracy-limiting factor because the load cell is guaranteed only to about 0.1%, and the output-vs-load characteristic is nonlinear (Fig. 2). The error caused by the nonlinearity can be reduced in many ways.

One method involves the use of a tapped potentiometer winding in the instrument. The resultant instrument characteristic then compensates for load-cell nonlinearity in linear segments (corresponding to the number of taps used). In this way the over-all system response can be made as close to linear as accuracy specifications require.

Linearity Correction Through Feedback

In those systems involving more than one load-cell transducer feeding a single indicator, the applied load is not always equally distributed between the transducers. Hence it is not possible to provide a single instrument characteristic which will compensate for all combinations of non-equal loading because an infinite number of over-all nonlinear characteristics are involved.

One method of overcoming this problem is the use of individual correction amplifiers for each transducer, as shown in Fig. 3. In this application of positive feedback, the cell output voltage is sampled by the correction amplifier and fed back with a polarity which reinforces the original excitation voltage. The over-all characteristic (e_o vs load) obtained from the circuit will be linear provided the amplifier gain is adjusted to compensate for the nonlinearity of the load cell.

The output signals from different load cells, each with such linearity correction, then can be added without error due to non-uniform loading.

Many additional factors must also be considered—temperature effects, transducer hysteresis and repeatability, and long-term stability. By careful selection of transducers and components it is possible to obtain a system accuracy shown in Fig. 4. In this figure the limit line is a plot of deviation from true reading as a function of applied weight. The limit lines represent a deviation of 0.1% of reading from full scale down to one tenth of full scale.

to 0.05%

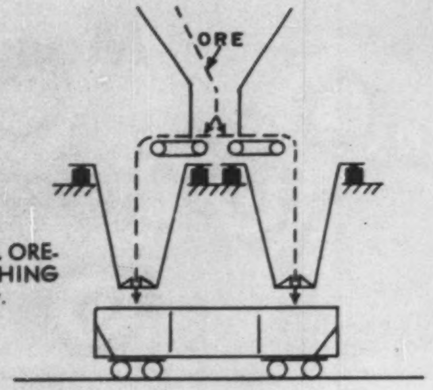


FIG. 6. ORE-WEIGHING facility.

It is necessary to know the transducer characteristics accurately. This requires a means of applying known loads to the transducer and precisely measuring the resultant output voltages. This is best accomplished by means of dead-weight and hydraulic-pressure machines which are checked and calibrated against standards maintained at the National Bureau of Standards, Washington, D. C.

Field Calibration Standard

Fig. 5 shows a field calibration standard which can be transported to the National Bureau of Standards to permit frequent and reliable calibration check of the weight system. This calibration unit has been used to calibrate missile stands using the load-cell compensation techniques described.

Fig. 6 shows a load-cell system for a modern ore-unloading facility built at Newport News by the Chesapeake and Ohio Railway. Weight detection components are temperature-compensated for operation over a wide ambient-temperature range. The weighing system includes totalizing, computing, and printing features, and corrects automatically for ore hang-up in the hopper. Interlocks guarantee that all operations maintain correct sequence.

The facility has two complete loading units, side by side. Each unit has two weigh hoppers, each of 50-ton capacity. The four weigh hoppers are on 20′ centers so that they can load evenly two railroad cars at one time. Each weighing hopper rest on four load cells of 50,000-lb capacity each, providing 200,000-lb gross hopper capacity. Each electric scale has a dial and capacity of −10,000 to +99,900 lb. A digitizing, totalizing, and computing unit is linked with a Monroe calculating printer.

Fig. 7 shows the recorders for a hot-metal ladle scale which measures ingot weight via loss-in-weight of pouring ladle (Fig. 1). Ingot weights are repeated within 100 lbs. The weight-sensing elements are in the ladle spreader beam; a circular indicator and control chassis are in the crane operator's cab (Figs. 7 and 8). The ladle can have up to 800,000-lb capacity.

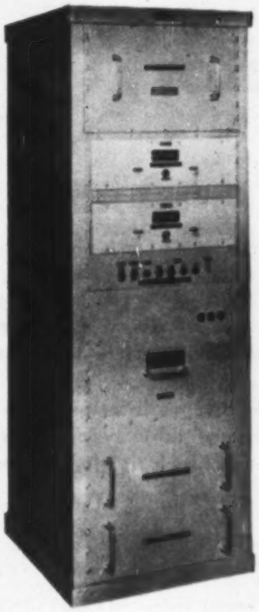


FIG. 5. FIELD calibration standard.

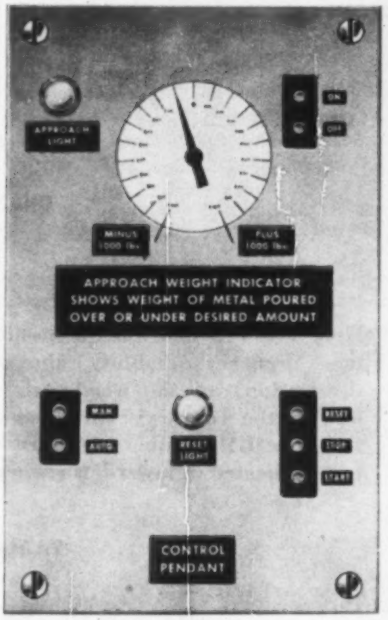


FIG. 7. WEIGHT indicator.

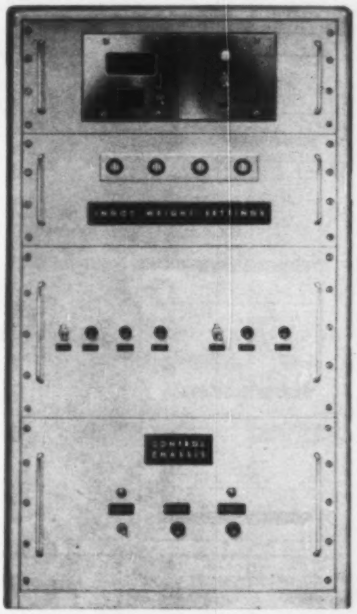


FIG. 8. CONTROL chassis.

Mass Standards

OF the four prototype standards, one (temperature) is already embodied in a physical constant, another (length) seems about to be, and a third one (time) is ready to be. What about the standard of mass? We can see no way of embodying that in a physical constant at present without detracting from the accuracy of our system. We seem to be "stuck" with the platinum-iridium kilogram. And is that bad?

Table 1 shows that the kilogram is the most precisely measurable of our prototype standards, that uncertainty in comparing it with other masses is about as small as the uncertainty in comparing the cesium second with the ephemeris second. What could cause the kilogram to change? Any damage to it which would remove 1 in 10^9 of its mass by a scratch or nick would be perceived readily by the naked eye. The oxidation of platinum at normal temperatures is so slow it has never been measured and no sign of an oxide coating on the metal has ever been noticed. We know of one calculable change which will take place in it. One of the isotopes of platinum, Pt 190, is radioactive. It undergoes α-decay with a half-life of about 10^{12} years. Since the abundance of this isotope is only 0.012% it will take about 10^8 years for it to produce a change as great as the imprecision of measurement. We do know that the Arago kilogram, produced during the first half of the last century, has exhibited a loss of mass of the order of a few milligrams. This kilogram was forged from a sponge platinum and must have had inclusions of gas which escaped. The kilograms of today are of fused metal and free from changes of this nature. There appears to be no good practical reason for replacing the kilogram with a physical constant.

TABLE 1—ACCURACY AND PRECISION IN MEASURING

Device	Magnitude	Accuracy (ppm)	Precision (ppm)
Cylinder	1 kilogram		0.005
Cylinder	1 gram	1	0.03
Cylinder	20 kilogram	0.5	0.1

Abstracts from paper "The Basis of Our Measuring System," by A. G. McNish, NBS *Proceedings of the IRE*, May, 1959.

Weight Standards Laboratory

CHARLES E. WHITE
AVCO Research and Advanced Development
Wilmington, Mass.

Here are the instruments used and the resultant measurement accuracy capability (shown at bottom of each block in illustration) of the weight and mass calibration section of one of the country's finest standards and calibration facilities. The EM numbers in third column of table refer to the tests indicated in lower-left corner of each block in illustration.

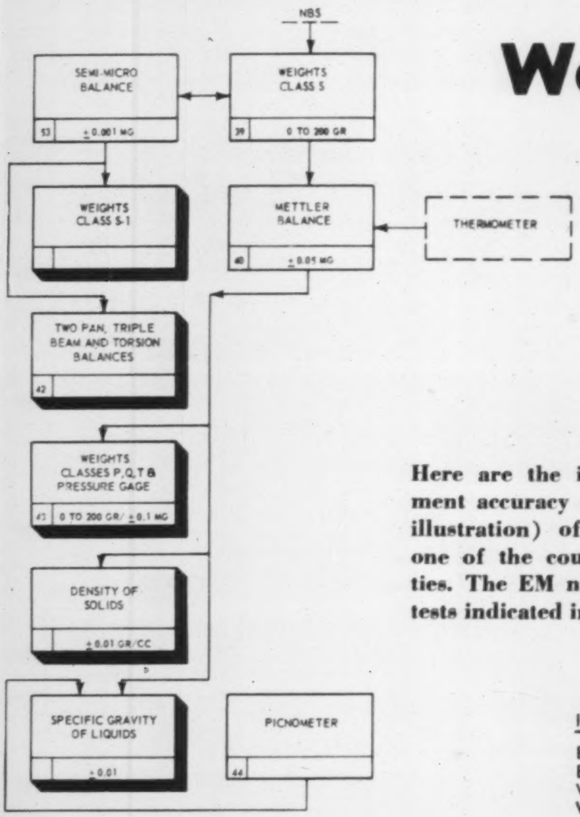


TABLE 1—EQUIPMENT

Item	Make & Model	Use
Balance, Analytic	MEG B-5 (Mettler Instrument Corp.)	EM40
Balance, Semi-micro	AIA TY-AW13 (Ainsworth & Sons)	EM53
Weights, English	RUD 2402 (Ruska Instrument)	EM15
Weights, Standard	ASA Class S (Ashcroft, MM&More)	EM39

STOP
MOTOR
BURNOUT

ASCO Close-Differential Relays provide dependable, low-cost protection from under and over voltage.

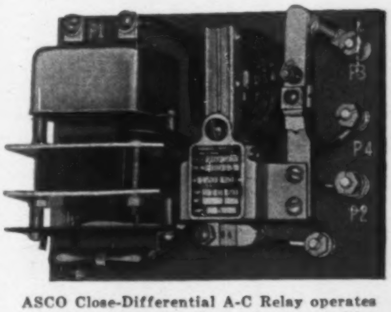
When a motor runs on low voltage for an extended period of time, burnout and fire may result. This can be costly in both down-time and damage to equipment.

You can protect your motors with ASCO Close-Differential Relays. They offer economical, dependable protection even when motor feedback conditions prevent ordinary potential relays from detecting changes in voltage. ASCO Close-Differential Relays respond to a 2% variation in voltage; protect motors when low voltage or over voltage conditions occur.

Because they combine sensitivity with rugged construction, ASCO Relays are providing low-cost protection in a wide variety of applications.

For example, in some oil burner installations, ASCO Relays help prevent explosions due to under voltage. In these installations, when under voltage occurs, ASCO Relays prevent oil build-up in the pit by detecting this low voltage condition, and causing oil flow to be cut off immediately. Otherwise on under voltage the oil would build-up in the pit since the ignition system would not fire. This excess oil could result in an explosion when voltage is restored and the ignition system fires.

Find out how the ASCO Close-Differential Relay can protect your equipment. Send for Catalog 57-S4 describing the complete line of ASCO Relays.



ASCO Close-Differential A-C Relay operates on 2% variation in voltage—features positive action, quiet operation, power relay type contacts.

Dependable control by ASCO is available from representatives and distributors in all principal cities.

ASCO Electromagnetic Control
Automatic Switch Co. 52-L HANOVER RD., FLORHAM PARK, N. J., FRONTIER 7-4600
AUTOMATIC TRANSFER SWITCHES • SOLENOID VALVES • ELECTROMAGNETIC CONTROL

ASCO

CIRCLE 63 ON READER-SERVICE CARD

AC INPUT
REGULATOR
MONITOR STANDARD
CURRENT DEVIATION DETECTOR
CURRENT SWITCHING NETWORK
METER UNDER TEST
FEEDBACK LINE
METER UNDER TEST
POWER SUPPLY
VOLTAGE DIVIDER
DIFFERENTIAL AMPLIFIER
REFERENCE POTENTIAL
GALVANOMETER
WESTON STANDARD CELL
FEEDBACK LINE

WESTON CONSOLE PROVIDES HIGHEST SPEED CALIBRATION

- **±0.05% accuracy of indicated value**
- **only one operator required**
- **for indicating, recording or digital instruments**

One operator can now calibrate or standardize most types of indicating, digital and recording-type instruments in 1/3 the time previously required by *two skilled technicians.* Designed for speed and simplicity, Model 61 Console is an ideal laboratory standard for periodic testing of other instrumentation.

Precisely adjustable calibration points are provided by this compact unit. AC ranges of 1 through 50 amperes may be subdivided into 30 equal parts . . . and up to 1,500 volts is available in 10 ranges with 75 to 300 divisions per range. In DC calibration, all full-scale ranges may be divided automatically into as many as 15,000 equal parts.

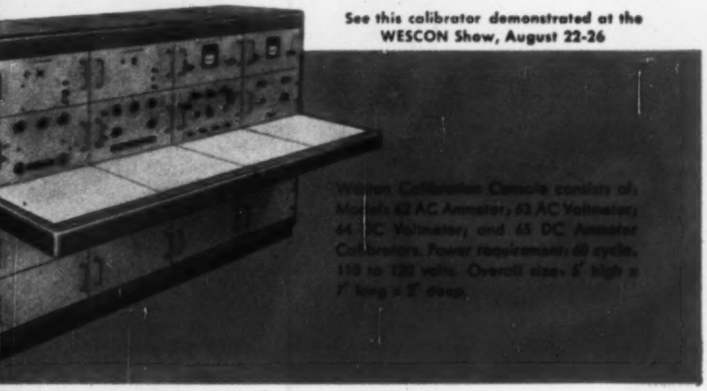
Accuracy of ±0.05% is achieved through proved Weston circuitry and high-precision standard cells. Any load variation, drift or deviation in either input or output voltage is instantaneously and automatically corrected. Phasing of AC units permits calibration of wattmeters at unity power-factor. For limited applications, individual units are available separately.

Call your Weston representative for complete details, or write for Catalog 06-101. Daystrom, Incorporated, Weston Instruments Division, Newark 12, New Jersey.

Export: International Sales Division, 100 Empire St. Newark 12, New Jersey.

In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ontario.

See this calibrator demonstrated at the WESCON Show, August 22-26



Weston Calibration Console consists of, Models 62 AC Ammeter, 63 AC Voltmeter, 64 DC Voltmeter, and 65 DC Ammeter Calibrators. Power requirement: 60 cycle, 110 to 120 volts. Overall size: 5' high x 7' long x 2' deep.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION
Reliability by Design

CIRCLE 18 ON READER-SERVICE CARD

Metering Viscous Flow

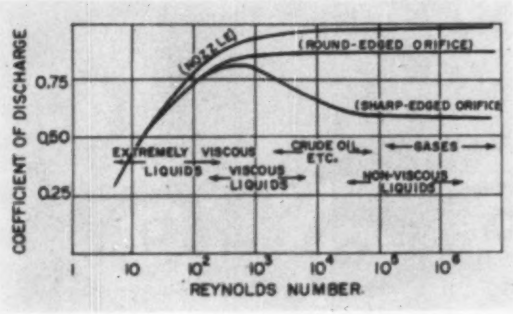


FIG. 1. SQUARE sharp-edged orifice has discharge coefficient which changes at Reynolds Number below 20,000. Round-edge orifice remains usable to Reynolds number down to 1000. (Courtesy American Meter Co.)

Accurate metering of high-viscosity fuel oils by ordinary metering techniques is a difficult operation. Here are recommendations based on the experiences of leading meter manufacturers for the "sticky problem" of metering liquids of low Reynolds number.

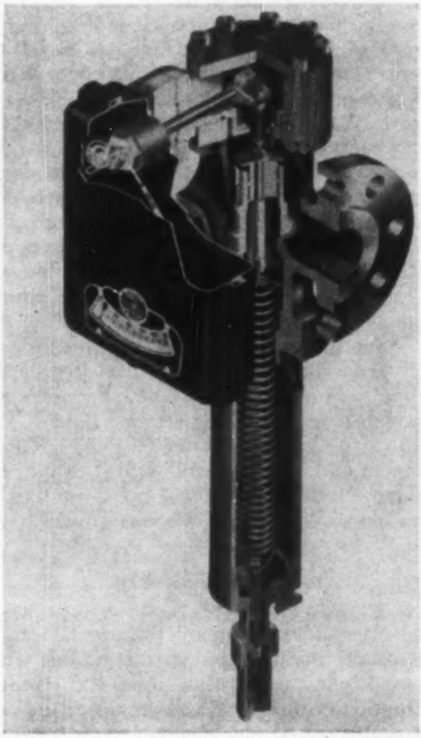


FIG. 2. BAILEY uses area meter for viscous fuels.

METERING VISCOUS FUEL oils presents special problems. As many of our readers have expressed an interest in techniques for metering viscous fuels, we asked several meter manufacturers for their recommendations; here they are.

American Meter

American Meter has sponsored investigations and research work with orifice meters in viscous liquids. Square-edged orifices show a considerable variation in discharge coefficient, increasing rapidly as Reynolds number falls below 20,000. Discharge coefficient is greatest around a Reynolds number of 300, then falls off again for lower Reynolds numbers (Fig. 1).

Tests with 2" and 4" lines revealed that a rounded-edged orifice (developed by American Meter) has a constant discharge coefficient for Reynolds numbers above 1,000. This orifice extends accuracy more than one decade lower in Reynolds number, and includes the viscosity range of crude oils (Fig. 1).

Bailey Meter Co.

Bailey recommends using the area meter (Fig. 2) when measuring heavy oils such as tar or pitch. These meters usually are installed with steam tracers or electrical heating cable, so that the meter itself as well as the fluid being measured is at an

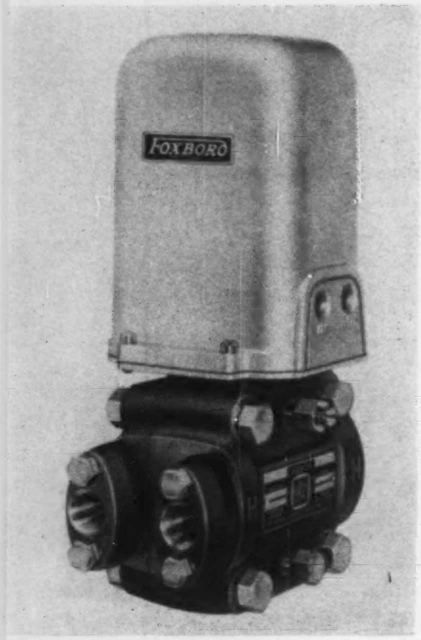


FIG. 3. FOXBORO uses quadrant-edge orifice and 13A d/p cell transmitter.

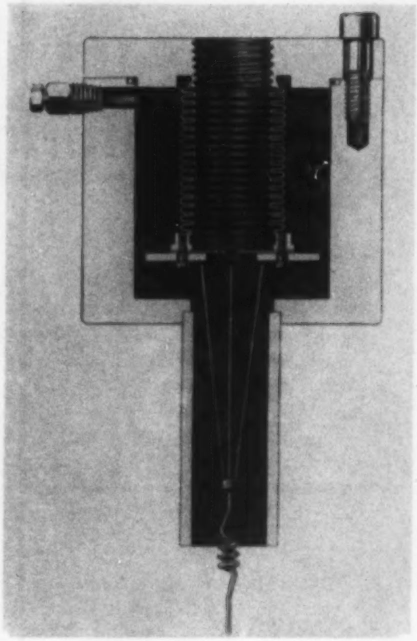


FIG. 4. HAGAN uses line-type differential transmitter with a bellows having a calibrated orifice.

elevated temperature.

In the case of the 4" size area meter, errors introduced by viscosity changes and manufacturing tolerances allowed in the gap between the metering plug and cage are so negligible that calibration under actual operating conditions is not required. This meter will stay well within the 2% accuracy guarantee when measuring fluids having viscosity as high as 300 SSU over temperature changes of as much as 200°F. It is sensitive to flow variations of ¼% of full scale and measures flow rate over a 50-to-1 range.

The smaller area meters (sizes 1" and 2") should be calibrated under conditions corresponding to actual use if a similar degree of accuracy is expected. The smaller meters require this calibration because the magitude of errors caused by both viscosity and manufacturing tolerances are inversely proportional to the total port area of the meter.

The problem of leakage due to manufacturing tolerances is caused by fluid passing between the metering plug lands and the cage and thus not producing the lift on the plug as required for measurement. This error, of course, is negligible in the 4"-size meter.

The viscosity error stems primarily from the fact that on the smaller area meters the relationship between the Reynolds number and coefficient of discharge is not a constant or linear function at low Reynolds numbers. As Reynolds number is a function of viscosity, which is in turn a function of temperature, every time the temperature of the measured variable changes, it results in a change in the coefficient of discharge and, hence, a change in indicated flow.

It is fairly simple to correct for both of these errors by calibrating the meter under operating conditions, using a fluid having the same viscosity as the fluid to be measured.

Satisfactory operation on tar and heavy oils apparently stems from the high differential across the meter and generous clearances between the cage and the metering plug.

Foxboro

Foxboro recommends a quadrant-edge orifice plate as the primary element for Reynolds numbers below 10,000. Accuracy is approximately 1.5% to 2% with constant coefficient.

Pressure taps from the flow line to the differential pressure device do not present much of a problem if treated in the following manner: Run the piping from both taps horizontally from the side of the flow line, through a shut-off valve, and into a vertical tee (the top of which has a plug so that filling fluid can enter). The piping from the bottom of the tee is brought directly to a Foxboro d/p Cell Transmitter. With shut-off valve closed, fill with a solution such as 50-50 Prestone and water, which is not miscible with line fluid.

The 13A d/p Cell Transmitter (Fig. 3) has small displacement and is recommended for this purpose. It also lends itself to small seal pots—another installation possibility where viscous products are involved.

Hagan

Hagan offers a flow-signal (differential) transmitter specially designed for viscous liquids which tend to solidify in a unit with a closed end (through which there is no flow). This transmitter, called a "line-type differential element" is shown in Fig. 4. It has a metallic bellows element with a calibrated

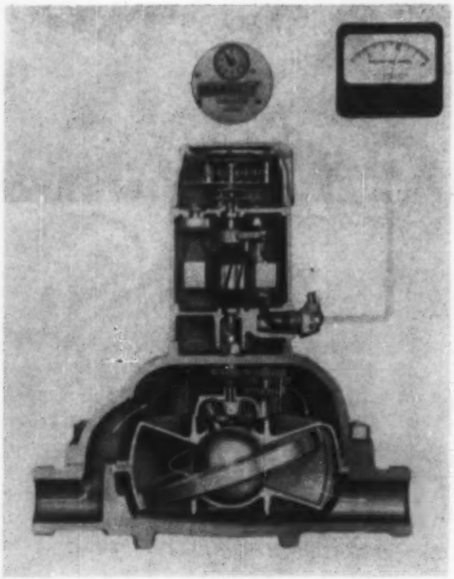


FIG. 5. HAYS uses Veriflow positive-displacement meter.

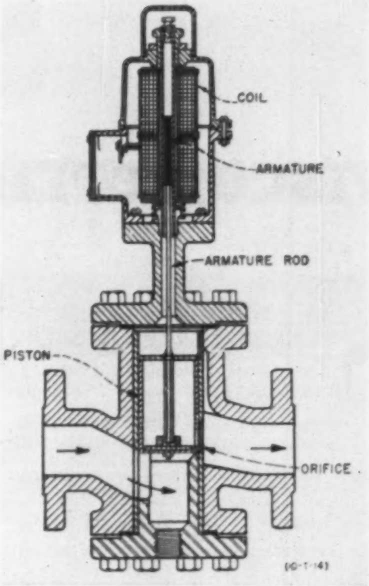


FIG. 6. MINNEAPOLIS-HONEYWELL uses area-type electric flowmeter for viscous fuels.

orifice in the bellows head.

If the flow is not expected to exceed 1200 gallons per hour and the viscosity of the liquid is not more than 150 SSU, and the temperature is not in excess of 300°F, the line type meter will not require an orifice plate in the line. In other words, all of the liquid is handled by the meter. If the flow is in excess of 1200 gph, an orifice will be required in the flow line together with the orifice in the transmitter bellows (the differential produced by the main orifice in the flow line causes a small flow through the orifice in the transmitter bellows, which thus can not "freeze").

Hays Corp.

Hays recommends the Model 347 Veriflow (and for control purposes, the Model 371 Veritrol) for measuring viscous fuels. The meter body itself is a Niagara or Buffalo metering unit, Hays adding the extension and generator with indicator as shown.

The metering body can be mounted within a suitable housing (standard 371 Veritrol case) which, together with a controller, power unit and suitable accessories, is applied to the control of such materials as tar, mollasses, fish solubles, and others.

Minneapolis-Honeywell

Minneapolis-Honeywell has an evenly-graduated area-type electric flowmeter (Fig. 6) designed for flow measurement of viscous liquids of over 40 SSU viscosity, such as Bunker "C" fuel oil, hot tar, asphalt, and 70%-solids black liquor. It is used on furnaces requiring ratio or cascade control of Bunker "C" fuel flow.

The inductance-bridge transmitter makes it possible to mount the recording-integrating instrument remotely on a panel, or with a second indicating controller actuated by the same transmitter and located close to the point of measurement.

Area-meter bodies are made for operation at 250 and 600 psig, at temperatures up to 600°F, and can be furnished with a cooling chamber section or low-pressure steam heating jackets. Flow is up to 30 gpm.

Accuracy of measuring depends on the conditions of installation and the fluids handled. However, this instrument is calibrated to 1% by the factory before shipment. Areameter coefficients are known to be about 2%; temperature and gravity effects are well known. Viscosity changes, however, are normally relatively minor. For example, a change in viscosity from 160 to 250 SSU (without change in temperature or gravity) will result in an error of only 0.5% on a 0.40" orifice sleeve and a 0-400 gph range. The same change on a 0.25" orifice sleeve and 0-200 gph range will require a correction of 1½%.

Republic Flow

Republic Flow Meters Co. reports tests conducted by a customer measuring viscous fuel oils. These tests reveal that a thin orifice with a rounded cross section and a small ratio has substantially reduced the measurement errors produced by viscosity change. The accuracy of such a measurement has not been definitely established, but it can be stated that this design is far superior to standard orifices and nozzles, which also were tested.

Abstracts from NBS
Circular 552, "Standard
Materials."

VISCOMETER CALIBRATING FLUIDS

STANDARD MATERIALS issued by the National Bureau of Standards, Washington, D. C., include the following oils for viscometers calibrated in poises, stokes, or Saybolt units.

The oils are not intended for use as *permanent* viscosity standards; they are not suitable for stockroom items and should be ordered only for immediate use. They are available only in containers of nominal 1-pint capacity. This quantity is sufficient for the calibration of most viscometers. Where a larger quantity is required, a satisfactory explanation of the need for the larger quantity must be given in the order or accompanying letter. All available liquids are hydrocarbon oils and are listed in the tables below.

Absolute or Kinematic Viscosity

The following oils are for use with viscometers calibrated in units of absolute or kinematic viscosity. The price covers the sample and a report containing accurate values at the time of shipment for absolute viscosity, kinematic viscosity, and density at the following temperatures:

Oils D through N	20°C, 25°C, and 40°C
Oil OB	30°C, 40°C, and 50°C
Oil P	20°C, 25°C, 100°F, and 210°F

Viscosity values at other temperatures in the range 20° to 100°C (30° to 100°C for oil P) are supplied as a special service. For oils D through N, the charge for this special service is $15.00 per sample per temperature. For oils OB and P, the charge is $32.00 per sample per temperature. These special service charges are in addition to the charge for the sample and usual report.

The approximate viscosities and the prices of the calibrating oils are as shown in Table 1.

Saybolt

The oils in Table 2 are for use with Saybolt viscometers. The price covers the sample and a report containing an accurate value at the time of shipment, for viscosity at the indicated temperature. Viscosity values at other temperatures or in other units are not supplied. Saybolt viscosity values are based on determined values for kinematic viscosity and the standard conversion tables published by the American Society for Testing Materials.

The approximate viscosities and the prices of the Saybolt calibrating oils are shown in Table 2.

TABLE 1

Oil	Absolute viscosity, in poises, at—				Kinematic viscosity, in stokes, at—				Price [1] per sample F.O.B. Washington, D.C.
	20° C	25° C	100° F	210° F	20° C	25° C	100° F	210° F	
D	0.020	0.018	0.014	0.006	0.026	0.023	0.019	0.008	$15.00
H	.074	.063	.044	.013	.091	.078	.055	.017	15.00
I	.12	.10	.066	.017	.14	.12	.081	.022	15.00
J	.21	.17	.11	.023	.25	.21	.13	.028	15.00
K	.41	.32	.18	.032	.48	.38	.22	.040	15.00
L	1.0	.74	.37	.049	1.1	.84	.43	.060	15.00
M	3.0	2.1	1.0	.099	3.4	2.4	1.1	.12	15.00
N	14	9.6	4.0	.25	16	11	4.6	.30	15.00

Oil	20° C	25° C	30° C	40° C	50° C	20° C	25° C	30° C	40° C	50° C	Price [1] per sample F.O.B. Washington, D.C.
OB	300	200	--------	55	--------	350	210	--------	60	--------	32.00
P	--------	--------	450	200	95	--------	--------	510	220	100	32.00

TABLE 2

Oil	Temperature ° F	Viscosity	Price [1] per sample F.O.B. Washington, D.C.
SB	100	300 seconds, Saybolt Universal	$6.50
SF	122	110 seconds, Saybolt Furol	6.50

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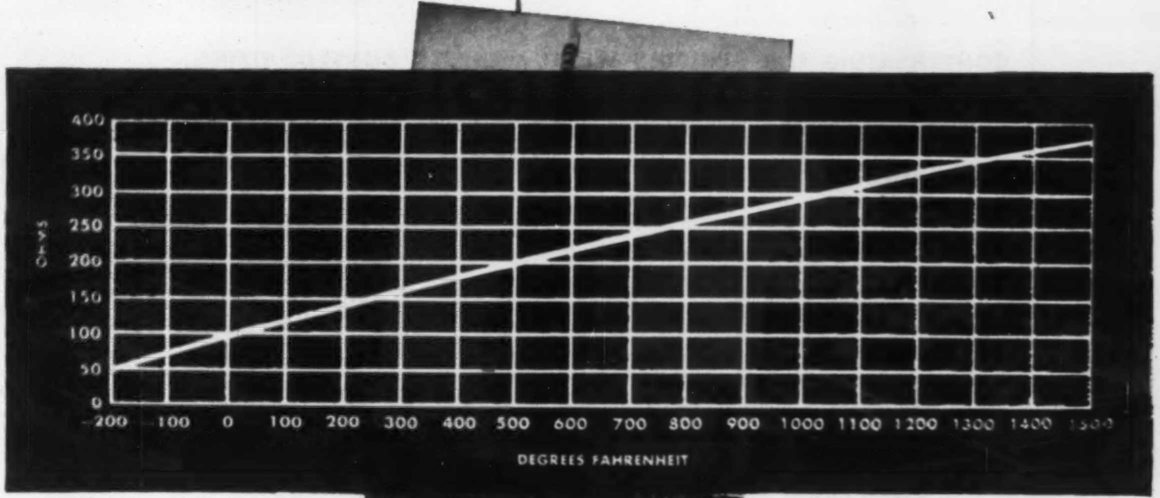
[1] Because of the nature of the material, samples of oils for use as viscometer calibrating liquids will be shipped via railway express, express charges collect.

WHEN IT IS VITAL* TO KNOW



T/R Characteristics of Model 242P
Edison Resistance Temperature Detector

*THE PRECISE TEMPERATURE

New manufacturing methods and new materials now enable Edison to offer a wide variety of Resistance Temperature Detectors for virtually any industrial temperature measurement. Edison RTDs indicate, record or control temperatures precisely and quickly, over a long period of years – without drifting, without maintenance and without errors due to ambient temperatures, stray elecrical fields, nuclear radiation, shock or vibration.

Because its principle of operation is based on the fact that the electrical resistance of metals increases with temperature, the Edison RTD is inherently accurate. Its accuracy is attested by the fact that in the temperature range of *minus* 300°F to *plus* 1220°F the platinum RTD is the International Temperature Scale. Since high-purity noble metals are used in the construction of Edison RTDs, they are extremely stable and reproducible. Their use in Wheatstone bridge circuits simplifies instrumentation by permitting the use of higher levels of power than is possible with either thermocouples or thermistors.

Standard detectors are available for use in the bearings of all types of machinery, to measure temperatures under nuclear radiation, on air compressors or in any chemical or petrochemical process. A wide variety of detectors for special purposes and for measurements to 1,800°F is also available from Edison, leader in the field.

Send for catalogue 3016 describing
Standard Edison Temperature Detectors or send
us your requirements for special detectors.

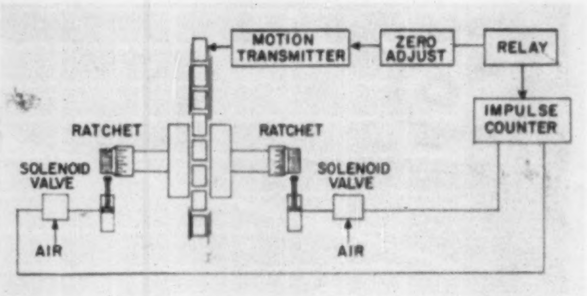
Thomas A. Edison Industries
INSTRUMENT DIVISION
24 LAKESIDE AVENUE, WEST ORANGE, N. J.

CIRCLE 65 ON READER-SERVICE CARD

Process Control Systems

FRED D. MARTON, Instruments Publishing Company

COMPENSATING FOR GRINDING WHEEL WEAR TO CONTROL SIZING



This system measures each piece ground and then positions micrometer dials to insure consistent tolerance as the grinding wheels wear.

Metal pieces are fed between two counter-rotating grinding wheels that have been positioned by micrometer dials as desired. Wheel wear causes oversize pieces, necessitating a repositioning of the micrometer dials.

Set-up to sense the thickness of each ground piece, the *Motion Transmitter* detects the first-oversize part resulting from grinding wheel wear. It uses an LVDT. The *Control Relay* then energizes solenoid valves to admit air to *pneumatic cylinders.* These cylinders drive ratchets fitted to the micrometer dials, which then correct the positioning of the worn grinding wheels to retain consisent sizing.

Pilot lights on the control panel indicate "correct" and "oversize" conditions. A control switch is supplied to effect manual or automatic system performance, as desired. *Zero Adjust* provides a reference for the tolerance to be measured by the Motion Transmitter.

An *Impulse Counter* precludes multiple corrections due to the accumulation of a few already ground pieces (between the grinding wheels and the sensing motion transmitter) following detection of the first oversize piece. Therefore, only one corrective positioning of the grinding wheels is made because the counter permits those few oversize pieces to pass the motion transmitter without causing successive corrective operations. The micrometer dials and ratchet assemblies on the grinder provide incremental positiong of 0.001" per step; the control system is capable of sensing and providing control for even finer tolerances.

Equipment used: Atcotran Motion Transmitter, using LVDT; Atcotran Zero Adjust (adjusts zero position of motion transmitter in relation to relay action); Atrotran Control Relay; ATC Impulse Counter; Two Solenoid Valves; Two Pneumatic Cylinders plus Ratchet Mechansim.

Source: Automatic Timing & Controls, Inc., King of Prussia, Penna., also Application Bulletin 103.

REMOTE LEVEL INDICATION OF OUTDOOR WATER STORAGE TANK

Level indication of water storage tanks is usually required at the pump house.

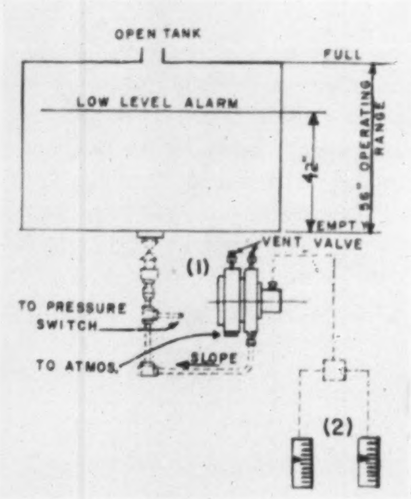
A system for a tank located 20 ft above ground uses a differential pressure transducer (1), mounted on the outside of the tank, and electronic indicators (2). Electric connection between the instruments is by 4-wire cable. (Maximum length is 3000 ft.)

The cell, which is of weather-proof construction, contains a diaphragm-actuated differential transformer. Low-pressure connection is to atmosphere, high-pressure connection is below low-water level.

The indicator has a printed-circuit transistorized amplifier and has 115-vac power supply.

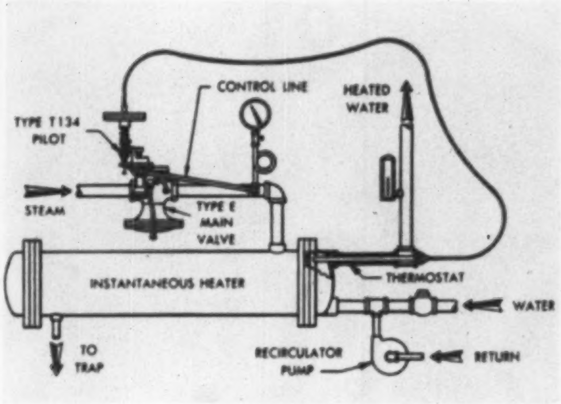
Equipment used: (1) Differential-pressure Transducer, Fig. 4313; (2) Electronic Secondary Indicator, Fig. 4355.

Source: Yarnall-Waring Co., Phila. 18, Pa.; also Bulletin RI-1825.



TEMPERATURE REGULATION

Heat exchange in a heater has certain definitive characteristics. The surface area of the heat-exchanger tubes, their coefficient of heat transfer, the liquid velocity at a given load (which governs the amount of time spent by a particle of water in the heater), all are relatively constant characteristics in any given installation and at any given load condition.



Only one factor can be varied to any degree by a regulator controlling temperature in a heater—the difference in temperature between heating fluid (steam) and heated fluid (water). The relationship of these factors is shown in the simplified heat-transfer formula:

$$Q = (U)(A)(t_s - t_w)(T)$$

where Q is the total heat flow in Btu; U is a coefficient measuring the rate per unit surface area at which heat can be conducted from the heating to the heated fluids with given tube materials; A is the area of heat-transfer surface; $t_s - t_w$ is the temperature gradient between the heating and heated mediums; T is the time during which a particle of the heated medium is in the exchanger and subject to heating.

The regulator controls the steam temperatures (t_s) by varying the steam pressure in the heater. A reduction in steam pressure reduces steam temperature. This is true even in the negligible number of cases where steam pressure reduction produces the superheated steam condition.

To shut off heat flow (Q) entirely, t_s must equal t_w. If t_w is below 212°F, t_s also must go below 212°F to stop heat flow. This means going *below* atmospheric pressure with steam in the heater. The removal of the resultant condensate under this operating condition is rarely ever provided for. Because heaters sometimes develop "hammer" when condensate collects, vacuum breakers often are installed to provide continuous drainage and to prevent heaters from going below atmospheric pressure.

With a vacuum breaker there is a portion of the load range through which the temperature regulator is not able to function reliably. A regulator faced with this situation frequently operates only on an on-off basis. After an off period, the heater coils become partially blanketed by air. Until removed, the air blanket causes the controlled temperature to drop and the regulator opens wider. This in turn leads to overheating. The regulator then will close and thereby start a repeat of this cycle.

Where vacuum breakers must be used (so that air can enter the system), there are two things to do: (1) install substantial air-eliminating capacity and (2) maintain heater capacity at minimum and thereby reduce the range of load over which sub-atmospheric control will be required. Too much heater capacity also has the adverse effect of narrowing the over-all pressure range through which the regulator may work, making its job more difficult.

Usually the best solution is to use an external recirculating loop with a good circulator. Such a loop provides the thermostat with the ability to monitor continuously the conditions in the heater with a minimum time lag.

Any regulator that operates far below its capacity can become unstable, and time lags in the system aggravate the situation.

The entire control system should be designed to achieve control stability. There are three basic rules which can be used as a guide in choosing suitable components:

1. Size the heater as small as possible.
2. Size the regulator for the smallest capacity that will carry the load with the available steam pressure and design heated pressure, i.e. available pressure drop.
3. Provide adequate condensate drainage for all operating ranges, and particularly for a vacuum condition.

If there is doubt as to how difficult the regulating job is, choose the more advanced regulator. Hot-water loads, even in apartment houses, can vary quickly and over wide ranges. Even if it turns out that the more advanced type of regulator is not really necessary, it will still provide better control than a regulator of lesser capabilities.

Source: Spence Engineering Co., Inc., Walden, N. Y.

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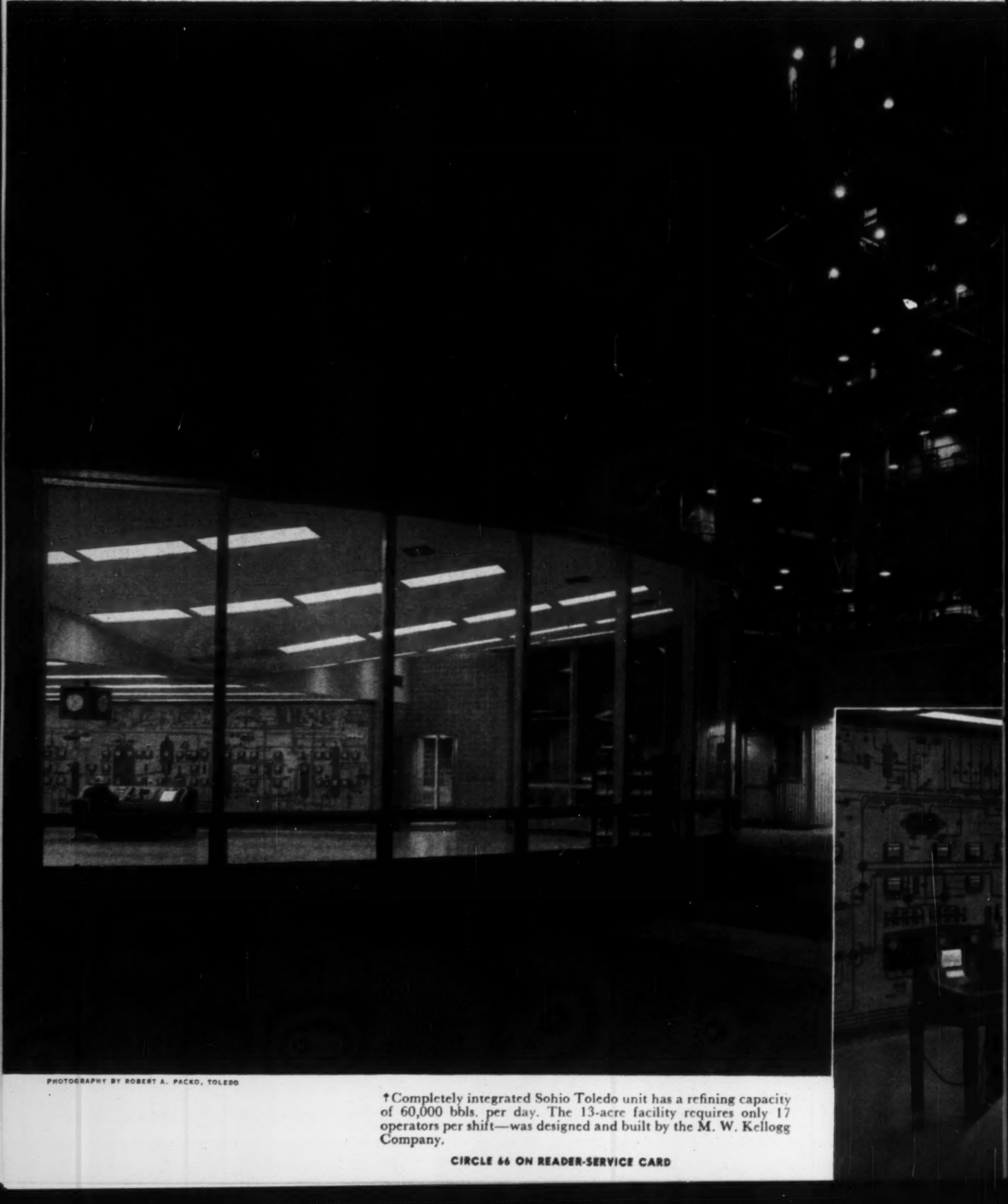

PHOTOGRAPHY BY ROBERT A. PACKO, TOLEDO

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↓Nerve center at Toledo is this 96-ft. Foxboro-instrumented control panel. Six "satellite" panels handle local control. Since unit must work as one continuous operation—or not at all—reliable instrument performance is essential.

Measuring Strain to 1000°F

Temperature change causes a strain gage to produce an undesired "apparent-strain" signal. The apparent-strain signal can be compensated by a bucking voltage from a thermocouple whose output is made to equal the apparent-strain signal. Either bridge excitation or thermocouple output or both can be adjusted.

A STRAIN GAGE subjected to temperature variation undergoes expansion or contraction and a corresponding resistance change, which causes an output identical to one caused purely by strain. This undesired output is referred to as *apparent strain*. A method has been devised to measure static strains up to 1000°F with a minimum apparent-strain error (+75 μin/in from 75° to 1000°F). The Micro-Test weldable strain gage Type SSE-4 and a thermocouple are used in this technique.

Technique

The apparent strain of a strain gage mounted on a base material is obtained in microinches/inch and plotted vs temperature (Fig. 1). Then, using the lowest temperature point as a reference (temperature at which bridge is initially balanced), a straight line is drawn from this point and made to cross the apparent-strain curve at a point or points which give equal amounts of strain above and below the line. The strains at highest crossover point (T_2) is noted. The voltage output from an appropriate thermocouple (E_o) corresponding to the temperature difference between the reference and crossover point is also noted. The bridge signal due to the strain gage is E(GNS)/4, where E is bridge excitation voltage. The gage emf signal and the thermocouple signal can be made equal by setting:

$$E(GNS)/4 = E_o \qquad (1)$$

E_o = open-circuit voltage (thermocouple output for the temperature difference between reference point T_1 and crossover point T_2).

G = Gage factor

E = Bridge excitation voltage

N = Number of active legs (1 for this case)

S = Apparent strain in microinches/inch for the difference between the reference and crossover point.

Adantage of this technique over one employing an unstrained dummy gage is the fact that it is possible to have a difference of 50-100°F from gage to gage under transient conditions.

One of the advantages of using the Micro-Test gage is that it can be placed in an oven previous to its installation on the base material and temperature cycled to determine the unmounted apparent strain error and the phase-change point.*

At LMSD, the weldable gages were superficially attached to a piece of metal by means of a metal ribbon and placed in an oven. The gage was connected in a bridge circuit using the three-wire method. The bridge excitation voltage was monitored and recorded while the output of the bridge was fed to the x axis of an x-y plotter. A thermocouple located at the gage was connected to the y axis, thereby giving a plot of apparent strain vs temperature. The oven was heated slowly (3 to 4 minutes) to the knee of the curve (the phase-change point) and then allowed to cool. Some gages were mounted on samples of the base material in order to obtain a correlation between the apparent strain of the gage itself and the apparent strain of the gage when mounted on the base material.

Formula (1) is used to determine the bridge excitation voltage. If the thermocouple output is too great and causes an excess bridge voltage for compensation, the thermocouple output E_o can be decreased by shunting it with resistors, thereby reducing the bridge voltage. Alternatively, if a certain bridge excitation voltage is desired and sufficient output from the thermocouple is available, shunts again can be successfully employed. The following equation is used in selecting the proper shunt resistor:

$$R_s = E_s (R_{TC})/(E_o - E_s) \qquad (2)$$

---

*Most of the commercial strain gages tested at LMSD exhibit phase changes between 850° to 1200°F as manifested by a drastic change in the slope of the apparent-strain curve (Fig. 1.)

R. L. HANNAH
A. M. KINAN
Lockheed Aircraft Corp.
Missiles & Space Division

where E_s = required voltage to cancel apparent strain, E_o = open-circuit voltage of the thermocouple between reference and crossover points, R_{TC} = resistance of the thermocouple, R_s = resistance of shunt across thermocouple.

Circuitry

The active gage is wired in a bridge circuit using the three-wire method to eliminate temperature effects due to a change in resistance of the leadwires (Fig. 2).

The thermocouple is installed as closely as possible to the strain gage (in the case of the Micro-Test gage, the thermocouple is spot welded to the flange of the gage) and wired in the output circuit so that the thermocouple output cancels the bridge output due to temperature.

To determine the proper connection for the thermocouple, reference is made to Fig. 2: If the apparent strain of the gage is positive, the negative lead of the thermocouple is connected to the bridge circuit at the output junction of the active gage and dummy gage. If the apparent strain of the gage is negative, the thermocouple is reversed.

The thermocouple can be used as an integral part of the conventional three-wire method as shown in Fig. 3. Note that the circuit is set up for a gage with negative apparent strain. If the thermocouple is grounded to the base metal, extra care must be taken to insure that no other ground is present in the bridge circuit.

Example

In order to show how the above information is utilized, a detailed example follows. Refer to Fig. 1:

T_2 = Temperature at highest crossover point = 948°F
T_1 = Temperature at reference point = 78°F
E_o = iron-constantan TC output for $T_2 - T_1$ = 26.59 mv
G = Gage factor = 1.85
S = Apparent Strain = 1640 μin/in
E = $4E_o/GNS$ = 35.1 volts

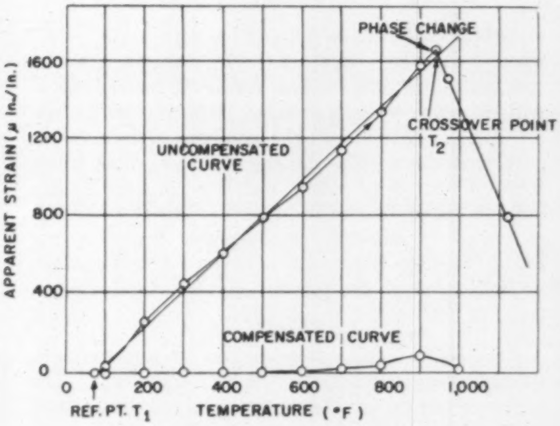

FIG. 1. APPARENT-STRAIN curve (temperature-output curve) for Type SSE-4 strain gage. Drastic change in slope is caused by phase change in the gage. An x-y recorder gives curve automatically.

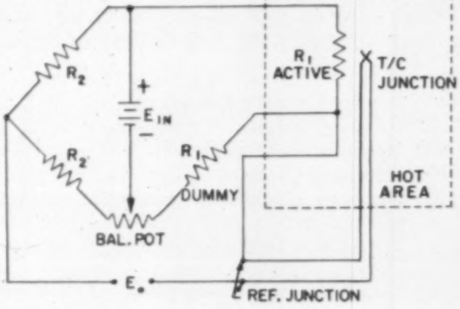

FIG. 2. COMPENSATING thermocouple connected into bridge.

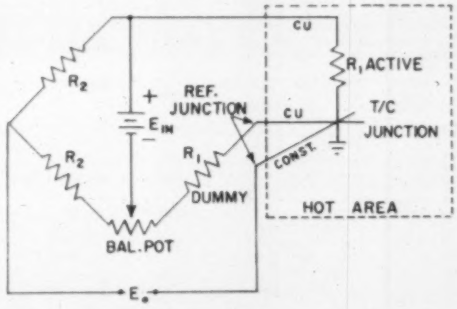

FIG. 3. THERMOCOUPLE can be integral part of 3-wire strain-gage bridge.

As this voltage is too large to be used with the strain gage, an arbitrary voltage of 7-v excitation was selected.

35.1/7 = 5.01. Therefore, the output of the thermocouple has to be decreased by a factor of 5.01

$$\frac{26.59}{5.01} = 5.31 \text{ mv} = \text{desired TC output} = E_s{}^{*}$$

Using Equation (2): $R_s = E_s R_{TC}/(E_o - E_s)$

$$= (5.31)(4.60)/(26.59 - 5.31) = 1.15$$

A resistance of 1.15 ohms across the thermocouple will decrease its output from 26.59 mv to 5.3 mv for T_2-T_1. Fig. 1 shows the compensated curve.

It was discovered during the tests that faster rates of heat application and lowering the bridge voltage result in elevation of the knee of the apparent-strain curve. For example, lowering the bridge voltage from 12.4 volts to 4.8 volts results in an increase in the phase reversal point by 35°F.

Results

In order to employ this method of compensation, the following conditions must be fulfilled: (1) The apparent strain of the gage mounted on a base material must be known and repeatable. Therefore, tests must be conducted on a sample of the base material in order to obtain apparent-strain readings. (2) The reference-junction temperature of the thermocouple has to be known and kept constant. Also, (3) it is necessary to accurately place the compensating thermocouple to correspond with the location of the thermocouple used in the initial apparent-strain setup.

The results of tests performed in the past indicate that apparent strain can be reduced from 85% to 98%, depending on the linearity of the apparent-strain curve. The more linear the curve, the better the results.

When one exceeds the temperature at which the phase change occurs and then returns to the reference point, he will find a change in the resistance of the gage. Hence the apparent-strain curve of the next temperature run will have a different slope and will require appropriate adjustments in the compensation. Therefore, it must be recognized that it is imperative to stay below this temperature, if repeatability from run to run is desired. However, for a single run, this method allows compensation slightly beyond the phase change point, thus explaining the method's usefulness to 1000°F.

---

*Equation 1 also could be used to obtain the same result, with E=7.0 v; E_s would then come out to be 5.31 mv.

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THE following calibration services are among those offered by the National Bureau of Standards:

201.101 Precision standard resistors.
201.102 Precision resistance apparatus.
201.103 Multi-megohm resistors.
201.104 Standard inductors.
201.105 Standard capacitors; tests with alternating current.
201.301 Standard resistors for current measurement.
201.302 Direct-current ammeters.
201.303 Direct-current voltmeters and millivoltmeters.
201.304 Alternating-current ammeters (20 to 30,000 c/s).
201.305 Alternating-current voltmeters (20 to 30,000 c/s).
201.306 Wattmeters.
201.307 Watthour meters.
201.308 Frequency meters for power frequencies.
201.309 Current transformers.
201.310 Voltage (potential) transformers.
201.311 Volt boxes
201.313 Instrument transformer testing sets (portable).

From Test Fee Schedule Revision, Part 201, *Electricity and Electronics*, Reprinted from the *Federal Register* of September 11, 1957 Vol. 22, No. 176.

Item	Description	Fee
201.101a	Determination of resistance in oil bath at 25° C. For all standards having resistances in the range 0.0001 to 100,000 ohms, inclusive, provided they are adjusted within 0.5 percent of a nominal value which is itself a decimal multiple (or submultiple) of 1 ohm	$20.00
201.101b	Determination of resistance in oil bath at 25° C. For odd-valued standards not falling within the scope of item 201.101a	25.00
201.101c	Measurement of resistance in oil bath at 20, 25, and 30° C., and determination of temperature coefficient. This test is made only when it is shown that the small changes in resistance resulting from necessary variations of the temperature from 25° C. are of importance	70.00
201.101d	Stability study and certification of 25° C. value of high-quality standards kept under observation for a period of at least 6 months. Each resistor	30.00
201.101z	For special tests not covered by the above schedule, advance arrangements must be made. Fees will be charged dependent on the time involved in making the test.	
201.102a	Precision rheostats and plug boxes, calibration and certification of corrections for decades not exceeding 10,000 ohms per step, 1 to 3 decades per box, each decade	$40.00
	For each additional decade above 3 included in one resistance box	25.00
201.102b	Megohm box, 10 sections each 100,000 ohms—calibration and certification of corrections	70.00
201.102c	Megohm box, unequal sections—calibration and certification of corrections	120.00
201.102d	Precision Wheatstone and colorimetric bridges of all kinds—calibration and certification of corrections	210.00
201.102e	Potentiometers, minimum steps 10 microvolts or more—calibration and certification of corrections	140.00
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201.102g	Kelvin bridge ratio box—calibration and certification of corrections	80.00
201.102h	Double ratio set for Kelvin bridge, with double set of fixed and variable arms—calibration and certification of corrections	210.00
201.312a	Determination of the values of current ratio and phase angle for settings of the dials of a portable current transformer testing set at 60 c/s	$172.00
201.312b	Determination according to 201.312a having been made, for corresponding determinations at 25 c/s	26.00
201.312c	Determination of values of the voltage ratio and phase angle for settings of the dials of a portable voltage transformer testing set at 60 c/s	172.00
201.312d	Determination according to item 201.312c having been made, for corresponding determinations at 25 c/s	14.00
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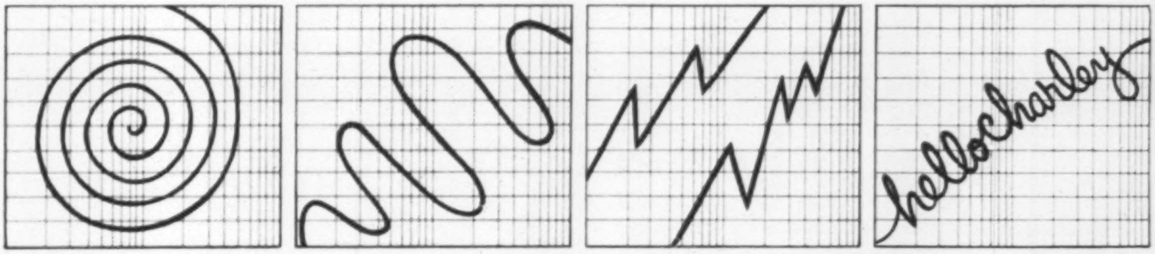

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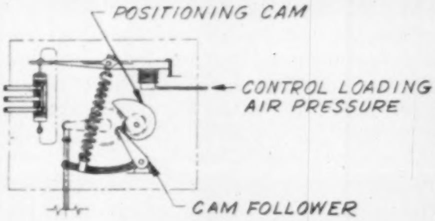

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The Engineering Shortage

ROBERT L. WEHRLI, Aeronautical & Instruments Div. Robertshaw-Fulton Controls Company

THERE is no shortage of technical talent in the United States—but there is a shortage of "available" technical talent in the United States! Why? What can be done?

There is a continual and growing shortage of available technical man-hours. Government and industry are consuming engineers and scientists at an alarming rate. With characteristic near-sightedness, technical people are being lured from educational posts to fill current requirements.

Further aggravation results from an apparent declining *effectivity* of technical personnel. Each year it appears that more engineers and scientists are required per technical job—despite the availability of computers and other new scientific tools created to relieve personnel for more demanding assignments.

Presented at 9th Annual Instrument Short course of the SCMA, April 13, 1960, Los Angeles Harbor College.

THE AUTHOR

Robert L. Wehrli is Vice President and General Manager of the Aeronautical and Instruments Division.

The growing need and the decreasing effectivity stem from a number of conditions. One such condition can be called "sidetrack"—the circumstance wherein a technical man leaves his profession for a non-technical or psuedo-technical activity such as purchasing or expediting, contracts or sales. There is also a promotional loss resulting from the divergent nature of managerial and technical tasks. There is also a preferential loss caused by the abandonment of a technical career in favor of "prestige" and independent endeavors. Lastly, there is the retirement loss which is aggravated by the ability of best men to earn retirement earliest.

"Sidetrack," the first of the problems stated, is aided and abetted in many cases by the extravagant and wasteful *project approach.* Slackening of progress on a project frequently results in the demand for enormous numbers of engineers and scientists. Furthermore, as an expediency, the project usually has authority to manage its own service functions and, in the interest of saving time, it assigns engineers to procurement, to contracts, to production, to routine testing, to customer liaison, to inspection, etc. Misuse of the project approach by government and industry increases the personnel loss due to defection. Many capable technical men are disillusioned by extravagant and wasteful projects, and seek other means of earning a livelihood.

Promotion loss is an industry problem. It is chained to an age-old practice of making "position" and "supervision" synonymous. In the eyes of every employee, including the technical man, advancement is toward management, and management means less connection with technical detail.

"Prestige" loss, the discarding of a technical career for an activity having more social status, deserves pity. It spreads as a function of social and economic pressure and, conceivably, could grow to be the major deterrent in the build-up of a technical force.

Retirement losses are quality losses. The man who has remained technical throughout his career represents the greatest reservoir of technical experience which is available. When he isolates this reservoir through retirement, the loss is not easily recovered. A man-year removed from the retirement end of a technical career cannot be replaced by many man-years of trainees. Experience can be replaced only by experience; therefore the shrinking productive span of the scientist or engineer is serious.

What Can Be Done?

Mankind may affect, and be affected by, its scientists and engineers, but relatively few groups can exert major influence on the manners and methods of the technical society. These few are (1) the government, which directly controls a large portion of the nation's technical effort; (2) industry, which offers long-term opportunity and consistent trends; (3) technical associations, which profess to administer to and represent their clientele; and (4) the individual scientist, engineer and technician.

A discussion of manpower utilization by *government* and *industry* is beyond the boundaries of this paper. It can be assumed, however, that both government and industry are interested in efficient manpower utilization and therefore, will be quick to adopt utilization concepts suggested by the technical profession.

Technical associations have the power and the position to promote professionalism and to teach talent conservation. Unfortunately, few such associations have done so.

There are hundreds of societies, all stressing communication of ideas—but actually spending more effort in selling advertisements in journals and touting regular national and international jamborees than in teaching their clientele to properly use training and experience. Note how few engineering societies require that members be professional engineers. The extent of the dilution can be measured by many existing trade publications. How many are really professional-level technical publications? Many are becoming trade journals. The real value of a technical society membership has, in many cases, degenerated to buyers guides, membership lists and new product notices. There is little professional leadership or guidance or education offered to the member in exchange for his dues, despite great protestation of "professionalism" and services.

Technical society conventions have become more useful to the salesman and to the personnel manager than to the engineer or scientist. The convention shows are now the market place for technical products, rather than the stock exchange for technical data. They are the auction marts for skilled workers, rather than the training halls for scientists and engineers. They are the Roman feasts, with all expenses paid, rather than the Senate halls, where problems and goals of the profession are considered.

Part of the problem with professional engineering and scientific societies lies with the number of such societies that exist. No one association is in a position to influence more than a small portion of the technical trade. This is unlike the American Medical Association, which serves virtually the entire medical profession. Similarly, the architectural association has gained great recognition and few architects fail to take advantage of the well-known AIA symbol. A coordinating association is needed by professional technical personnel and steps should be taken to generate one. Under no circumstances, however, should this society assume the role of a union.

The *technical man* himself can exert the greatest influence in effective utilization of technical talent. First, he must assume the responsibility for driving and guiding a strong technical association. Second, he must work to retain technical activity as he advances up the management ladder. Third, he must recognize that, as a professional man, he is devoting his talent, not his time, and in doing so he must chain his consciousness to the task. Finally, he should look forward to using his experience and training even in retirement, through teaching in his area of competence.

August Meeting: **Thursday, August 18, Rio Hondo Country Club, 10627 Old River School Road, Downey, California.**

Subject: **Valve Operator Control Systems for Compressor Stations, by Mr. Howard Ledeen, Ledeen, Inc., El Monte, Calif.**

S.C.M.A. HANDBOOK

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The handbook sells for $7.50 to members of the Association and $10.00 to non-members. Inquiries should be directed to the Secretary of the S.C.M.A. Revisions and additions are made periodically.

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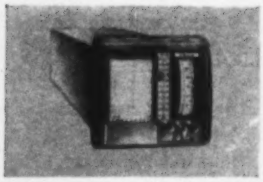

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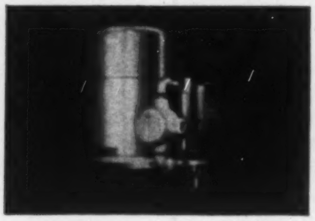

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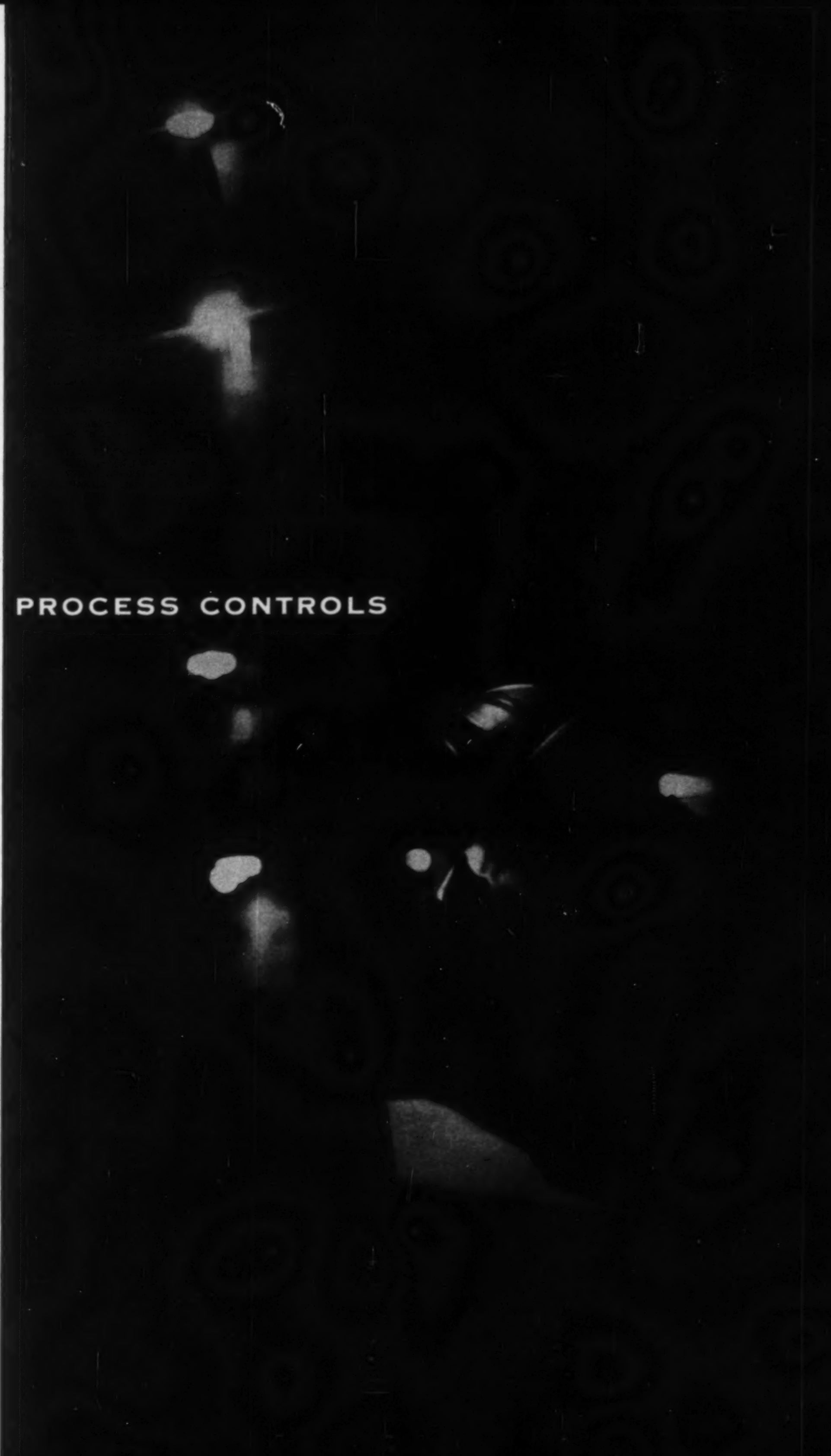

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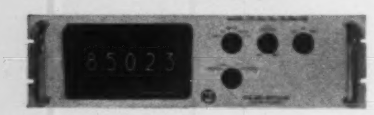

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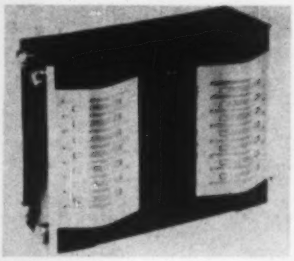
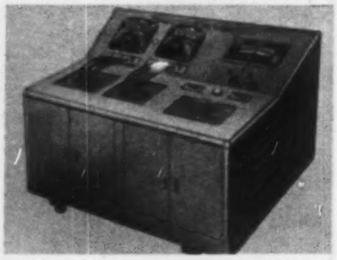


CIRCLE 163 ON READER-SERVICE CARD

CALIBRATION STAND



New portable Calibration Stand which fully meets thermocouple calibration requirements of MIL-E5009-B on jet engine pre- and post-acceptance tests, is 4' wide x 3' deep x 3' high and is available in many models, which differ only in the number of furnaces and types of readout systems used. Illustrated is Model 125-1, capable of accepting 6 jet engine tailpipe thermocouples at each of two temperatures. Readout is directly in degrees deviation from a reference.—*Harco Labs., Inc., New Haven, Conn.*

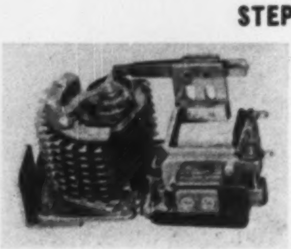
CIRCLE 164 ON READER-SERVICE CARD

CONTROL PANELS

New Instrument and Control Panels contain pneumatic and electric controls within the totally enclosed cubicle. Graphic section consists of plexiglas sheet with flow lines and symbols silk-screened on rear of sheet. Panel can be removed if it is necessary to change flow system.—*Lake Erie Electric Mfg., Inc., 2952 West 22nd St., Erie, Pa.*

CIRCLE 165 ON READER-SERVICE CARD

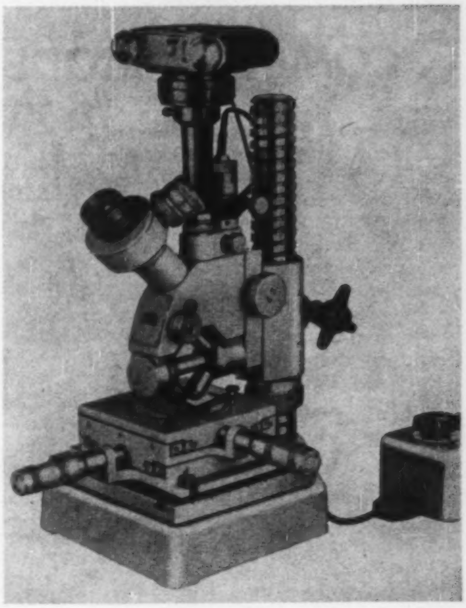
STEPPING SWITCH



New 10-point Stepping Switch, Type 210, specially designed for digital operation, is small (maximum length is 4 5/16") and lightweight (1½ lb with 12 levels), and available with a wide variety of hermetically-sealed or dust-cover enclosures. Terminals or connectors to suit application.—*C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Ill.*

CIRCLE 166 ON READER-SERVICE CARD

FOR FURTHER INFORMATION USE CARD ON PAGE 1215



Important advantages offered by this

LIGHT SECTION MICROSCOPE

MADE BY **CARL ZEISS** WEST GERMANY

This microscope produces a profile of the surface being examined by the well known light-section method. Roughness depth, as well as groove distances of machine-finished surfaces, can be measured. Internal surfaces can be examined by making lacquer replicas.

The newly developed revolving nose-piece for the objectives makes it possible to quickly change the magnification (height of profile) between 400x and 200x. At 400x, depths of roughness of 40 to 160 micro inches can be measured; at 200x, those of 120 to 4,000 micro inches.

Photographs for comparison and control purposes can be taken by mounting a 35mm miniature camera at top of the instrument.

In addition to the stage plate of the stand, a mechanical stage and center cradle (for turned parts) are available.

Write for detailed literature.

CARL ZEISS, INC. COMPLETE SERVICE FACILITIES

485 FIFTH AVENUE, NEW YORK 17, N. Y.

CIRCLE 70 ON READER-SERVICE CARD

EPLAB

Thermopiles

For many years the thermopile has been the accepted instrument for measuring Radiant Heat from Radiant Heaters at the American Gas Association Testing Laboratory in Cleveland, Ohio. Since 1930, when Vandaveer first described his work in this field,* an Eppley thermopile has been used for this purpose in hundreds of tests and the results have been consistent and accurate to within 1 per cent.

This is but one of many applications in the field of radiant energy measurements for which Eppley Thermopiles are ideally suited. They may be obtained with windows of different materials, and various types of black are available for receiver coatings.

All Eppley Thermopiles are supplied with a certificate of calibration, this calibration being made against a Standard Lamp from the National Bureau of Standards.

If you have a problem involving the measurement of radiant energy we invite you to write us, describing your problem in as much detail as possible. We will be glad to make recommendations and there will be no obligation.

***Vandaveer, Industrial & Engineering Chemistry, Vol. 22, page 596, June 1930.**

BULLETIN No. 3 ON REQUEST—Address: 2 Sheffield Ave., Newport, R. I.

THE EPPLEY LABORATORY, INC.

SCIENTIFIC INSTRUMENTS

NEWPORT, RHODE ISLAND, U. S. A.

CIRCLE 71 ON READER-SERVICE CARD

D-C AMPLIFIER EVALUATION *number 3 in a series*

COMMON MODE REJECTION

Low level d-c signals produced by strain gages or thermocouples are best amplified by differential input d-c amplifiers. A differential input d-c amplifier is one which measures the difference between two voltages regardless of the absolute value of the voltages.

The schematic (Fig. 1) shows a differential input amplifier, the difference or differential mode voltage (E_d), and the total voltage common to both input terminals (termed the common mode, E_c).

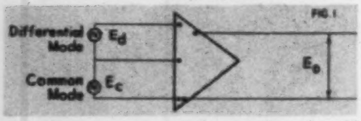


FIG. 1

"Common mode rejection" (C.M.R.) refers to a differential input amplifier's ability to measure E_d without errors due to E_c. It is proportional to the ratio of common mode voltage and the equivalent differential input voltage produced by the common mode voltage or

$$\text{C.M.R.} = \frac{E_c}{E_o \text{ due to } E_c} \times \text{gain.}$$

Rejection is generally given for a-c as well as d-c common modes.

Testing amplifiers for Common Mode Rejection

To determine the C.M.R. of a given differential input d-c amplifier, the input is shorted and connected to a source of common mode voltage as shown. Both d-c and a-c values should be applied and the amplifier output measured with devices of suitable sensitivity (Fig. 2). The C.M.R. is calculated by dividing the product of amplifier gain and common mode voltage by the observed output voltage due to the common mode voltage. Since some amplifiers suffer a decrease in gain with a common mode voltage, amplifier gain should be checked with common mode voltage applied. When simulating a differential mode signal, care should be taken to provide an appropriate source of impedance oriented to ground in a manner similar to that of the actual transducer used. For information showing these procedures in detail write for Bulletin BE AN123.

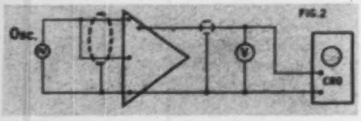
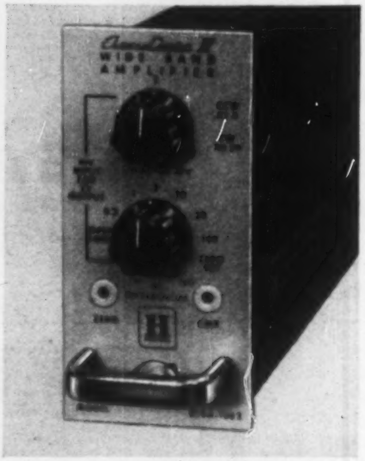


FIG. 2

Less than 0.02% error

Honeywell AccuData II Differential Input D-C Amplifier is specified to have common mode rejection of 1,000,000 at d-c, 200,000 at 60 cps, and 5,000 at 400 cps, with full scale differential input of 3 to 30mv Maximum allowable common mode voltages are 100 v d-c, 15 v pk at 60 cps, and 3 v pk at 400 cps. Adjustment of a C.M.R. balance on the front panel compensates for up to 5 ohms unbalance in either input lead. Thus, either a 1 v 60 cps or 5 v d-c common mode voltage applied to the AccuData II produces only 5 μv eq. in error signal, or less than 0.02% of the 30 mv full scale input signal.



The AccuData II has single-ended as well as differential input ranges, input impedance of 2 megohms differential (20 megohms single-ended), and power output sufficient to drive the highest frequency galvanometer oscillograph to its maximum deflection. In addition to excellent common mode rejection, the unit offers exceptional zero stability and linearity, very low noise and frequency response to 20 kc. For complete specifications on common mode rejection as well as on other characteristics of the AccuData II, write for Bulletin BS-DISA-1000 to Minneapolis-Honeywell, Boston Division, Dept. 50 40 Life Street, Boston 35, Mass.

Honeywell

First in Control

SINCE 1885

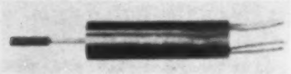
CIRCLE 72 ON READER-SERVICE CARD

ANGULAR POSITION TRANSDUCER

New Angular Position Transducer which provides continuous and accurate measurement of angular displacement in test applications of servo systems on aircraft control surfaces, valve positioners, and radar scanners of limited travel, incorporates a high-strength metal beam, onto which are bonded special SR-4 strain gages. The gages are electrically connected to form a balanced Wheatstone bridge.—*Baldwin-Lima-Hamilton Corp., Electronics & Instrumentation Div.*, 42 *Fourth Ave., Waltham* 54, *Mass.*

CIRCLE 167 ON READER-SERVICE CARD

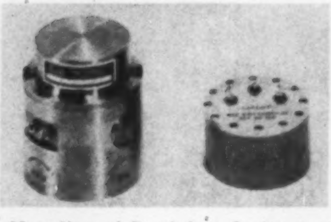
SOLID-STATE TRANSDUCER



New line of Displacement Transducers operates with d-c excitation and provides a d-c output signal. Features include reliability, infinite resolution, large stroke-to-length ratios, extreme accuracies, and large output signals. Available with germanium components for 6 vdc excitation, and with silicon components for 10 vdc excitation.—*G. L. Collins Corp.*, 2820 *E. Hullett St., Long Beach, Calif.*

CIRCLE 168 ON READER-SERVICE CARD

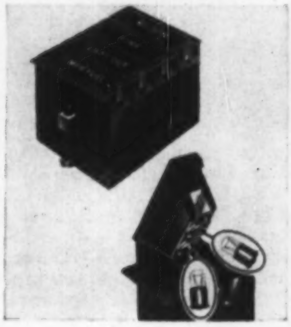
INCLINOMETER



New line of Pendulum Instruments with potentiometric outputs, Series 5 Pendulum, provides positive indication of pitch and roll attitude of non-accelerating platforms. Models are available in many different configurations, both single-axis and two-degree-of-freedom versions, with various degrees of rotation. Basic models measure pitch and/or roll attitude within 0.1°. Meets or exceeds other environmental conditions as specified in MIL-E-5272.—*Edcliff Instrument*, 1711 *S. Mountain, Monrovia, Calif.*

CIRCLE 169 ON READER-SERVICE CARD

PLACARD LIGHTS



New Twin-lamp Placard Lights provide a means of illuminating legends on rectangular legend plates. Legends are inscribed on plates which act as the lenses. Maximum legend area is 1 3/16" x 9/32"; the type is 0.135" high for one row of characters (11 max); 0.115" high for two rows of characters (11 max). Each light houses two T-1¾ midget flange-base incandescent bulbs of 6, 14, or 28V as required. Four Series of "Placard Lights" are available: Series VM281 (2-terminal); Series VM-282 (3-terminal); Series SW287 (4-terminal, normally open).—*Dialight Corp., 60 Stewart Ave., Brooklyn 37, N. Y.*

CIRCLE 170 ON READER-SERVICE CARD

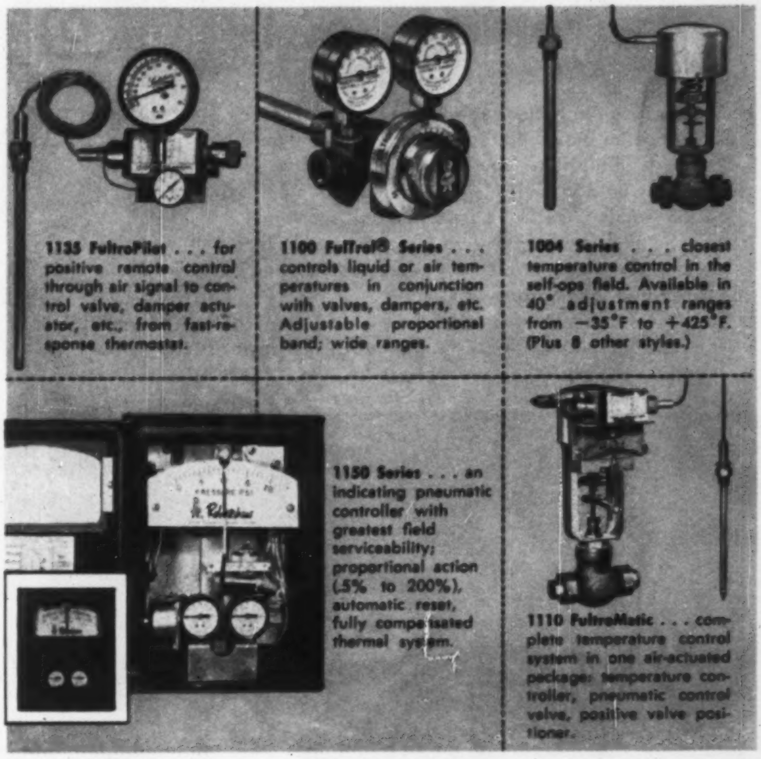
S.S. PRESSURE CONTROLLERS

New series of Pressure Controls has all parts in direct contact with the pressure medium made of Type 316 s.s., including the Bourdon tube power element, and bottom pressure connection. The internal mechanism is nickel plated. Outside adjustments provide easy setting of operating points. The visible calibrated dial tells the exact operating points at which control is set. Ther hermetically-sealed mercury contact provides a quick means of determining whether circuit is on or off. Operating ranges are 30" vac to 75 psig; 10-100 psig, 30-400 psig, 75-800 psig, and 100-1000 psig. Differentials are available for general pressure applications, for applications requiring close differentials, or where very close (sensitive) differentials are needed.—*Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.*

CIRCLE 171 ON READER-SERVICE CARD

FROM SELF-OPS TO INDICATING CONTROLLERS . . .

Sure Control at Low Cost ...and Quality All the Way!



1135 FultroPilot . . . for positive remote control through air signal to control valve, damper actuator, etc., from fast-response thermostat.

1100 Fulfrol® Series . . . controls liquid or air temperatures in conjunction with valves, dampers, etc. Adjustable proportional band; wide ranges.

1004 Series . . . closest temperature control in the self-ops field. Available in 40° adjustment ranges from −35°F to +425°F. (Plus 8 other styles.)

1150 Series . . . an indicating pneumatic controller with greatest field serviceability; proportional action (.5% to 200%), automatic reset, fully compensated thermal system.

1110 FultroMatic . . . complete temperature control system in one air-actuated package: temperature controller, pneumatic control valve, positive valve positioner.

From the rugged simplicity of self-ops to the more complicated requirements of an indicating controller, Robertshaw answers your temperature control needs — efficiently and economically.

And whichever Robertshaw instrument best fits your particular job, you know there's quality all the way . . . quality of design, construction, performance.

Check the Robertshaw temperature and pressure controls for *your* needs. You'll find them shown in detail in Catalog A-NL. **Fulton Sylphon Division, Robertshaw-Fulton Controls Co., Knoxville 1, Tenn.**

Robertshaw

MR. CONTROLS

CIRCLE 73 ON READER-SERVICE CARD

HEISE GAUGES

Something More Than
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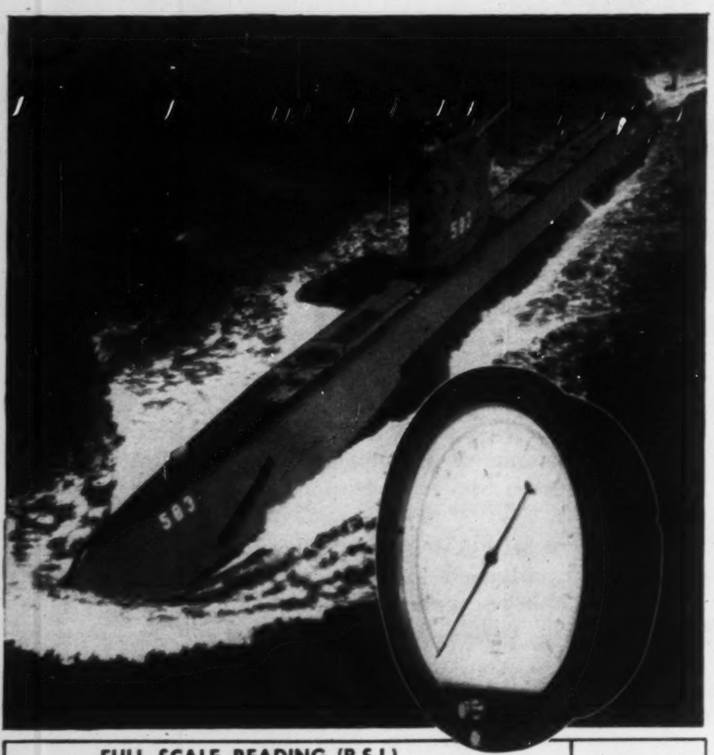
Standards of accuracy for instruments used in testing reactor plants in nuclear powered submarines may be achieved only by superior design and scrupulous workmanship.

The Heise Bourdon Tube Company provided pressure gauges used in initial tests of the power plant designed for the USS Nautilus, the first atomic powered submarine.

Heise Gauges were also used during initial testing of reactor plants on the atomic powered submarines, Skipjack, Skate, Swordfish, and Sargo.

Heise Laboratories design and manufacture pressure measuring instruments for the most advanced research and development projects.



	FULL SCALE READING (P.S.I.)				
OVER	15	5,000	20,000	30,000	40,000
INCLUDING	5,000	20,000	30,000	40,000	50,000
DIAL SIZE	PRICE F.O.B. NEWTOWN, CONN.				
8½"	$166.75	$186.75	$216.75		
12"	$190.50	$210.50	$240.50	$250.50	$260.50
16"	$232.25	$252.25	$282.25	$292.25	$302.25

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FOR MOST
RANGES

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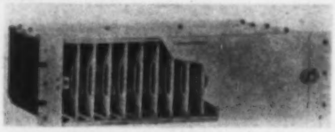
CIRCLE 74 ON READER-SERVICE CARD

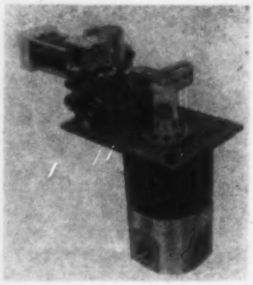
TRANSISTOR SWITCHING UNIT



New compact Transistor Switching Unit, Trans-Switcher, accepts up to 100 different on-off signals and within 100 μsec displays graphically the signal condition on a direct writing sequence recorder. Having no moving parts, it contains ten plug-in decade boards with each one capable of handling 10 signals in a wide range of voltages and pulse shapes. Mode of operation can be SPST, SPDT, or DPST.—*Brush Instruments, Div. of Clevite Corp., 37th and Perkins, Cleveland 14, Ohio.*

CIRCLE 172 ON READER-SERVICE CARD

SHEAR-SEAL VALVES



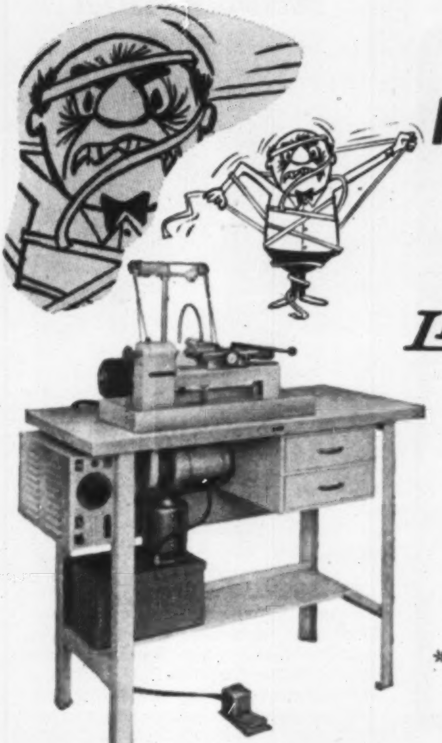
New Cylinder-operated Valves are rated for 10,000, 6000, and 3000 psig hydraulic oil or water; and 10,000, 4000, and 200 psig air. Available in 4-way, 3-way, and shut-off flow patterns. Port sizes range from ¼" thru 1½" NPT. Operators are obtainable with cushioned or non-cushioned cylinders for 8 to 250 psig air pressure and for 500 psig maximum oil or water pressure.—*Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.*

CIRCLE 173 ON READER-SERVICE CARD

PENCIL PROBE T/C

New design probe-type Thermocouple features less than 10-msec response time to transient temperature, a continuous service temperature of over 2000° F, will take transient temperatures to melting point of material, and a sensing tip with unlimited life. It can be used as an immersion thermocouple, on the surface, or on in-wall applications. Wire materials include Fe-Constantan, Chromel-Alumel, Cu-Constantan and Pt-Pt/10% Rh. Bulletin TB-259 gives details.—*Nanmac Corp., Box 8, Indian Head, Md.*

CIRCLE 174 ON READER-SERVICE CARD



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* Smallest commercial drill available.

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NEW ELECTRO-MAGNETIC DISC BRAKES

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STYLE "HTC" 50 SERIES

°For stub, extended, or thru-shaft applications on motor ratings from ⅙ to 2 hp

°NEW Torque Range 1½ to 15 lb ft

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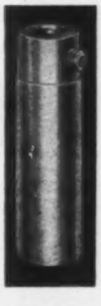
CIRCLE 76 ON READER-SERVICE CARD

NORCROSS VISCOMETERS

for Automatically Measuring Viscosity in the process with the

PROVEN FALLING PISTON



Typical Applications:

1-Solvent Control—Solvent is automatically added to correct for evaporation losses in Finishing (flow coating, dipping and spraying), Wire Coating (enamel, plastic, rubber, etc.), Rotogravure Printing, Sizing and various coating processes.

2-End Point Determination—Viscosity is automatically recorded during polymerization and other chemical processes. All changes show as they occur so that the process can be terminated at the correct viscosity.

3-Starch Processes—A Recording Viscometer is used to automatically control starch cooking or enzyme converting to finish each batch accurately to the desired viscosity.

4-Petroleum Processes—General refinery applications and various blending processes.

HIGH SENSITIVITY

RUGGED CONSTRUCTION

SELF CLEANING

WIDE VISCOSITY RANGE

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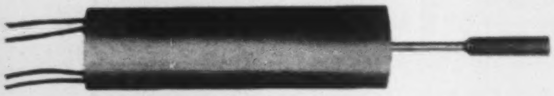
DISPLACEMENT TRANSDUCERS

with **BUILT-IN SOLID STATE** *circuitry*

To permit dynamic measurements with micro-inch resolution



SPECIFICATIONS

Excitation: to 24 VDC

Range: ±.050" to ±50"

Scale Factor: to 100 V/in. DC

Linearity: 0.5%

Dynamic Response: exceeds 1000 CPS

Resolution: infinite

Stability: 0.1% F.S.

Temperature: to +275°F

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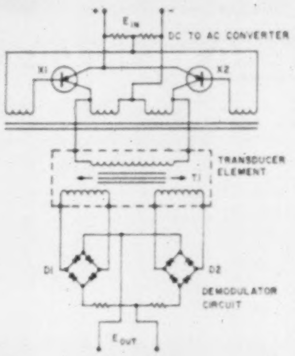

G. L. COLLINS GLC CORPORATION

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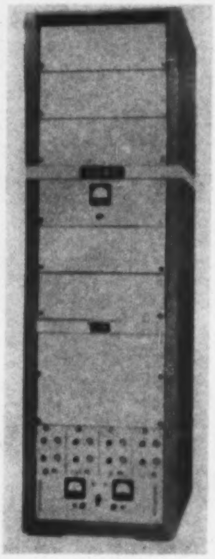
CIRCLE 79 ON READER-SERVICE CARD

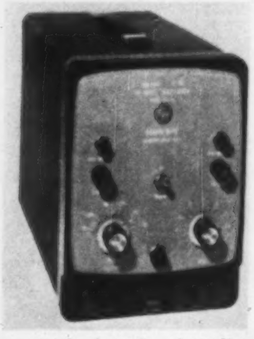
MULTIPLIER CONSOLE



New Diode Electronic Multiplier Console, Model C404-13, employing solid-state devices in the multiplier shaping networks, is a completely self-contained unit, which incorporates eight channels of multiplication, eight A400-1 d-c computing amplifiers, a power supply and a metering panel. The multipliers have a static multiplication accuracy of 0.125%. By addition of a special electronic circuit (also available in kit form) this accuracy can be increased to 0.05% Maximum amplitude error is 0.5% at 100 cps.—*Reeves Instrument Corp., Components Marketing Div., Garden City, N. Y.*

CIRCLE 175 ON READER-SERVICE CARD

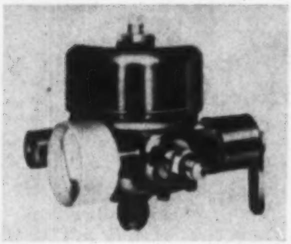
WIDE-BAND AMPLIFIER



New wide-band, low-distortion Power Amplifier, Model DCA-10, features a power output of 10 watts, continuous, from dc to one Mc, with frequency response flat within ±1 db, throughout the entire frequency range. Voltage gain is continuously variable, maximum of 10. Suited for general-purpose laboratory use, computer systems, vibration analysis, etc.—*Krohn-Hite Corp., 580 Mass. Ave., Cambridge 39, Mass.*

CIRCLE 176 ON READER-SERVICE CARD

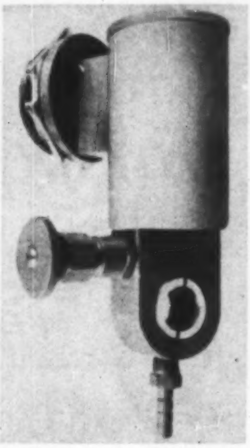
OXYGEN REGULATOR



New fully-automatic, continuous-flow, altitude-compensated Oxygen Regulator is designed to supply a wide variety of pressures for emergency use by jetliner passengers and crews. With little or no modification, the 1½-lb device can deliver any flowrate normally encountered in the air transport industry, within ±1 psi of the desired pressure. By use of a surge valve with which the regulator can be equipped, the system pressure can be brought up to the desired level (40 to 80psi) for opening the mask-compartment door latches, and then cut out of the system to allow normal programmed pressures. An additional feature is a solenoid-actuated valve which permits the pilot to actuate the unit from the cockpit.—*Robertshaw-Fulton Controls Co., Aeronautical and Instrument Div., Santa Ana Freeway and Euclid Ave., Anaheim, Calif.*

CIRCLE 177 ON READER-SERVICE CARD

GRAVITY POUR SYSTEM



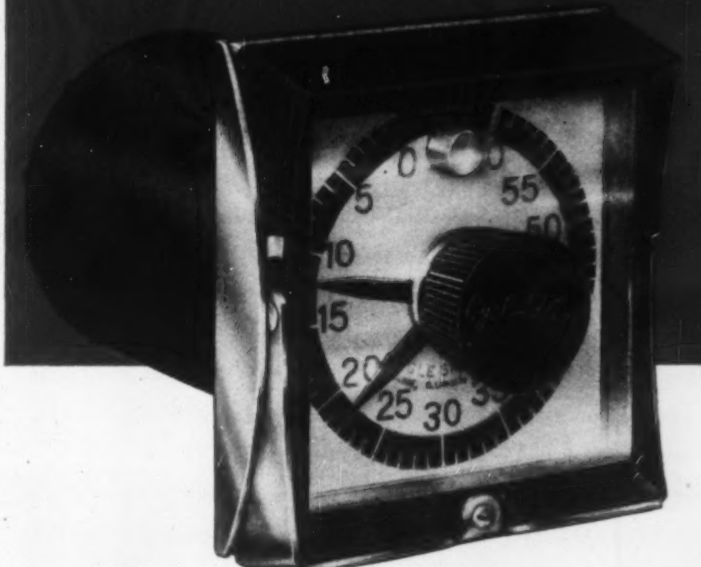
New pumpless, gravity-metering Pour-Portioner Drop-rate Feeder, designed for use with air conditioning, cooling tower, and corrosive plant chemicals, features a built-in, head loss equalizer, giving constant, same-rate flow from full to empty. Bulletin contains details.—*Sterling E. Norcross Cos., 19 Osborne St., Bloomfield, N. J*

CIRCLE 178 ON READER-SERVICE CARD

new plug-in timer

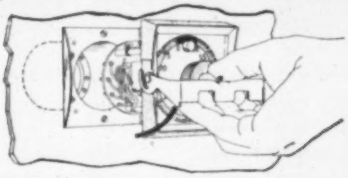
for controlling industrial processes

EAGLE'S HP5 CYCL-FLEX



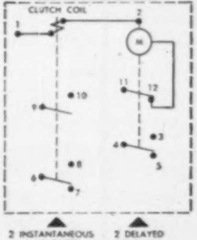
Offers:

- *Fast, easy installation*
- *Quick change of time ranges*
- *Quick means of localizing trouble*



To Remove: Lift handle and pull out

INTERNAL TIMER FUNCTION SHOWN SCHEMATICALLY



With 4 switches — 2 switches operate instantly when timer is energized — 2 switches operate with time delay — delay time adjustable — selection of dials from 10 seconds to 60 hours. Write Dept. IC-760.

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PRODUCTION ENGINEERING SHOW
SEPT. 6-16 1960
NAVY PIER, CHICAGO
BOOTH NO. 381

EAGLE SIGNAL COMPANY
Moline, Illinois

The Most Complete Line of Time-Count Controls

CIRCLE 80 ON READER-SERVICE CARD

Today's sophisticated buyer of scientific and business data processing equipment knows that expandability, efficiency, and simplicity of operation must be considered right along with speed specifications. ***The Bendix G-20, with "organization chart" design offers an optimum combination of* ALL *these features that you'll find in no other system ... at any price!*** **To see why, compare the G-20 to an efficient business organization. The "boss" of the system is the Central Processor ... a very fast digital computer. Unlike other data processors which must direct every operation, this boss delegates many of its responsibilities to highly skilled "line supervisors," called control buffers. These units direct input-output operations, data transfers and code translations—independently, but under program control. The Central Processor remains free to do the work that only it is qualified to do ... high speed computing, as well as scheduling and directing the work flow in the proper order of importance.**

This "organization chart" efficiency is what makes the G-20 system so fast and economical. It makes multiple, simultaneous operations completely practical, and with a minimum of equipment. The G-20's own management skill eliminates most operator decisions.

Truly modular, a G-20 system can vary in size from medium-scale to very large. Note carefully the specifications below. Check them against any other data processing system you wish ... then compare price. You will see why we can state so confidently that ***the Bendix G-20 offers unequalled performance for your data processing dollar. Write or wire for detailed descriptive literature.***

Bendix G-20

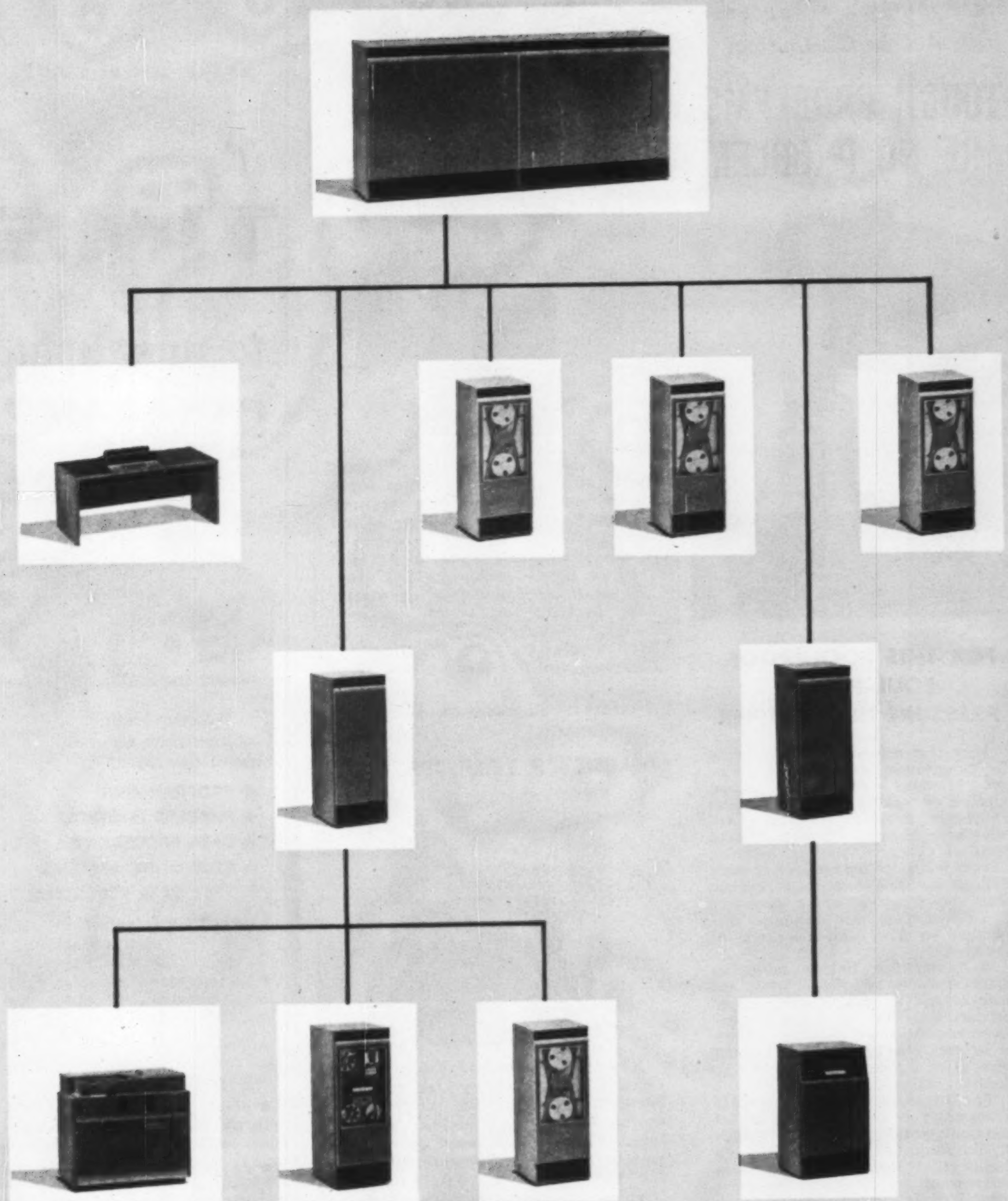
with organization chart design means unequalled performance for your data processing dollar

SPECIFICATIONS: MEMORY: Core, to 32,768 words in 4096 word modules. **EXECUTE +:** 7µs. avg., fixed point, one-word precision. 13 µs. avg., floating point, one-word precision. **EXECUTE ×:** 49 µs avg., fixed point, one-word precision. 49 µs. avg., floating point, one-word precision. **ARITHMETIC:** Built-in floating point, 12 decimal digit precision. **CIRCUITRY:** Solid-state; parallel; 2.5 kva. **PROGRAMMING:** Algebraic compiler or symbolic assembler. **INPUT/OUTPUT:** 165,000 character/second max., asynchronous. **MAGNETIC TAPE:** 120,000 decimal digit/second read-write. **LINE PRINTERS:** 600 lines per minute. **PUNCHED TAPE:** 500 or more character/second readers. 100 or more character/second punches. **PUNCHED CARDS:** Standard high-speed 80 column units. **CONTROL BUFFERS:** 1024 character memory for data and commands. Controls transmission on-line or off-line.

Bendix Computer Division
DEPT. J-26 LOS ANGELES 45, CALIF.

Bendix

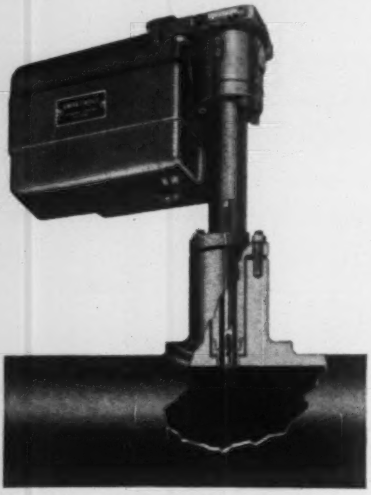
CIRCLE 81 ON READER-SERVICE CARD



ORGANIZATION OF A TYPICAL MEDIUM SCALE G-20 SYSTEM

Great things are happening in AutroniC® Control

TOUGH PROBLEMS ARE NO PROBLEM



FOR THIS FOOLPROOF, FOUL-PROOF PRESSURE TRANSMITTER

Here is a primary sensing element for those tough jobs you'd like to forget. Mounted right on the process pipeline or tank, the Swartwout Flush Diaphragm Pressure Transmitter will effortlessly measure pressure or liquid level of polymers, slurries, asphalts, viscous fluids, molten metals and other difficult media. No stagnant pressure lines, no steam jacketing necessary . . . the stainless steel transmitter diaphragm fits flush with the inside of the vessel.

A friction-free linkage multiplies diaphragm motion and actuates the core of a differential transformer to produce a 0-0.5V AC signal for any Swartwout AutroniC indicator, recorder or controller. Sensitivity is better than 0.005%, reproducibility 0.1%, accuracy 1.0%.

The Flush Diaphragm Pressure Transmitter is just one unit in the constantly-growing AutroniC family of electronic instrumentation . . . a family that includes all necessary components for complete electronic control of any process parameter.

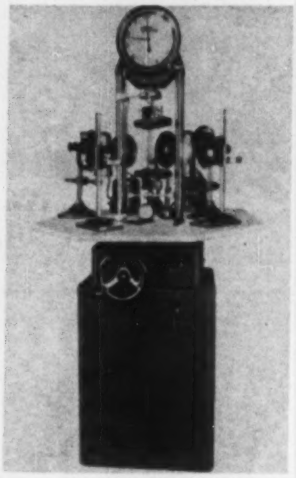
For details on the Flush Diaphragm Pressure Transmitter, request Bulletins A-713 and A-718. Swartwout Division, Crane Co., Hooksett Industrial Park, Manchester, N.H.

SWARTWOUT

. . . world leader in electronic process instrumentation

CIRCLE 82 ON READER-SERVICE CARD

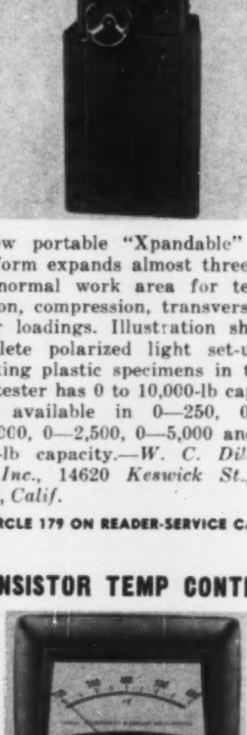
TESTER WORK BASE



New portable "Xpandable" Work Platform expands almost three times the normal work area for tests of tension, compression, transverse, and shear loadings. Illustration shows a complete polarized light set-up for checking plastic specimens in tensile. The tester has 0 to 10,000-lb capacity. Also available in 0—250, 0—500, 0—1,000, 0—2,500, 0—5,000 and 0 to 7,500-lb capacity.—*W. C. Dillon & Co., Inc.*, 14620 *Keswick St., Van Nuys, Calif.*

CIRCLE 179 ON READER-SERVICE CARD

TRANSISTOR TEMP CONTROLS



New transistorized Temperature Control Units employ factory-calibrated thermistors. By using interchangeable printed circuit boards, several models are available with a variety of modifications. The Series 536 Unit Controller, e.g., covers a temperature range from -50 to 600° F, with a sensitivity of 0.3°F, and current handling capacities of 10 amps 110 vac, and 5 amps @ 230 vac. It is a single-point controller with either ON-OFF or proportioning action. The Series 580 Indicator is a panel-mounted unit. A third unit, designated Series 561, is a transistorized single-point ON-OFF temperature indicator and controller with an optional proportioning circuit.—*Fenwal Incorporated, Pleasant St., Ashland, Mass.*

CIRCLE 180 ON READER-SERVICE CARD

it's
TIME
to investigate

PARABAM DIGITAL CLOCKS

The Parabam Digital Clock provides accurate time-of-day for . . .

- ★ **PROGRAMMING**
- ★ **PROCESS CONTROL**
- ★ **DATA PROCESSING**
- ★ **COMPUTING SYSTEMS**
- ★ **TEST DATA RECORDING**

up to 86,400 contact combinations.

- ● Time-of-day readings in increments of one minute, tenth-minute or one second.
- ● Multiple or single outputs in decimal code and various codes of binary coded decimal.
- ● Single plane, in-line lamp bank display. 1" high numerals. (Display also available for remote mounting.)
- ● 24 hour or 12 hour AM-PM configurations.

WRITE TODAY—
for Technical Bulletin No. 460-5 on the Parabam Digital Clock.

PARABAM, INC.
13000 YUKON AVENUE
HAWTHORNE • CALIFORNIA

ENGINEERING • DEVELOPMENT
MANUFACTURING

CIRCLE 83 ON READER-SERVICE CARD

THREE-IN-ONE VALVE

New-configuration 6000-psi Metering Valve, Series T180, can be used as a three-port valve with two ports in common, as a globe valve, or as an angle valve. Valve features all-stainless-steel construction with a weight of only 1.06 lb, $\frac{3}{16}$" dia flow passage, excellent metering characteristics, and low operating torque.—*Robbins Aviation, Inc., 2350 East 38th St., Los Angeles 58, Calif.*

CIRCLE 181 ON READER-SERVICE CARD

RECORDING CHART PAPER

New inkless, heat-sensitive Recording Chart Paper, known as Heatrace, is supplied in opaque and translucent grades. Bulletin gives details. —*Nashua Corp., 44 Franklin St., Nashua, N. H.*

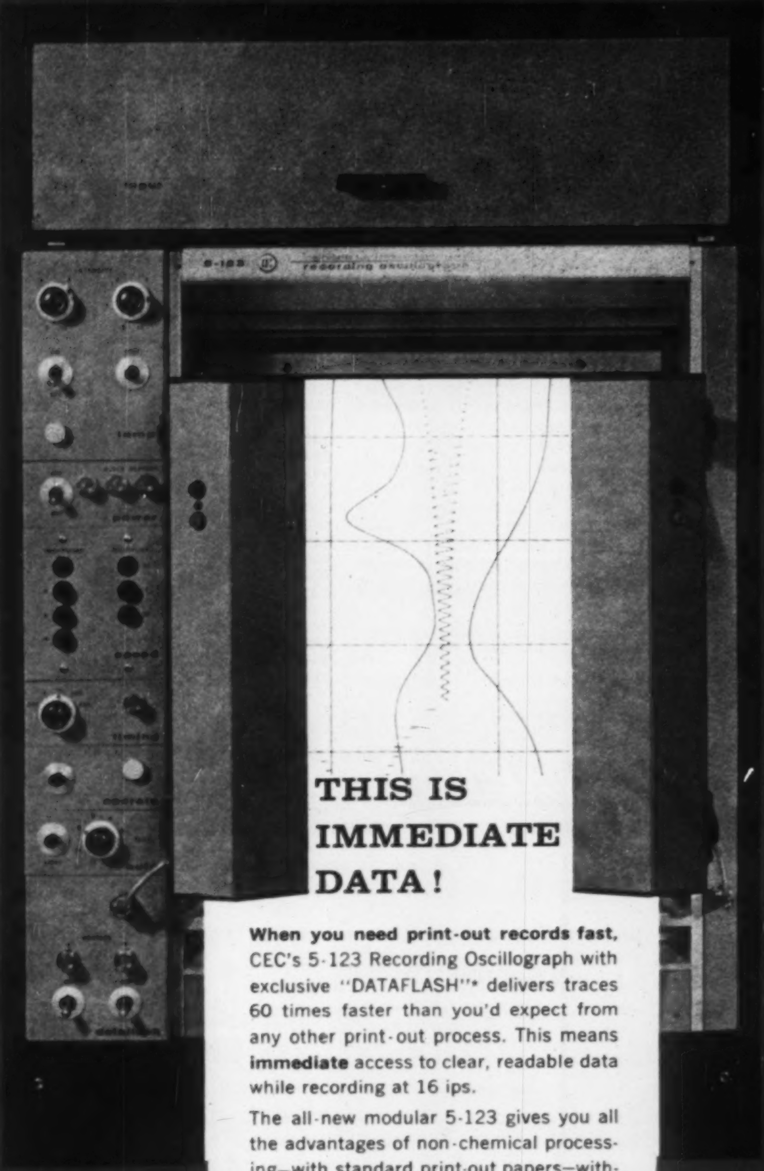
CIRCLE 182 ON READER-SERVICE CARD

STORAGE DEVICE

New line of rotating-magnetic-disc Storage Devices, the BD-100 (Bernoulli Disk) Series, is for commercial applications. The flexible rotating disc of paper-thin magnetic mylar material maintains a small, controlled separation between the storage disc-medium and the read/write heads of the memory unit through utilizaion of basic fluid motion principles. Reliability is extremely high, with virtually no possibility of damage to the recording medium or to read/write heads. Weight is but a fraction of conventional storage drums. 7½" in dia it stores 100,000 bits of information on 32 tracks, up to 3,000 bits per track.—*Laboratory for Electronics, Inc., 1079 Commonwealth Ave., Boston 15, Mass.*

CIRCLE 183 ON READER-SERVICE CARD

CIRCLE 84 ON READER-SERVICE CARD ⟶



THIS IS IMMEDIATE DATA!

When you need print-out records fast, CEC's 5-123 Recording Oscillograph with exclusive "DATAFLASH"* delivers traces 60 times faster than you'd expect from any other print-out process. This means **immediate** access to clear, readable data while recording at 16 ips.

The all-new modular 5-123 gives you all the advantages of non-chemical processing—with standard print-out papers—without latensification delay.

The last word in mounting versatility... Rack it vertically, lay it horizontally for table-top use, or stand it on a bench. The 5-123 is unmatched for versatility. You'll also like its full front accessibility and pushbutton controls that change speeds instantly from 0.1 to 160 ips while recording 36 to 50 channels of data.

For complete information, contact your nearest CEC sales and service office, or write for Bulletin CEC 1623-X6.

*Patent Pending.

Electro Mechanical Instrument Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

A SUBSIDIARY OF Bell & Howell · FINER PRODUCTS THROUGH IMAGINATION

GILMORE

PORTABLE DIGITAL INDICATOR & LOAD CELL CALIBRATOR

Now Available from Stock

- **DIRECT READING**
- **AUTOMATIC BALANCE**
- **0.1% ACCURACY OR BETTER***

The Model 170 is both a high accuracy portable field indicator and a calibration standard for weight, force, and thrust measuring systems. Because of increased customer acceptance and demand, the Model 170 has been made available from stock. Recently accepted as secondary standard by Air Force for use in calibration vans, the Model 170 is being used in over 300 installations for (1) missile weighing, (2) jet and rocket engine thrust measurement and calibration, and (3) tank weighing.

For complete specifications, request Gilmore Bulletin D-103.

*Higher accuracies on request.

Manufacturers of: Multi-Channel Plotters • Weighing Systems • Thrust and Force Measuring Systems • Strain Gage Instrumentation • Digital Indicating Potentiometers • Data Loggers

Instrumentation Systems for Industry and Science

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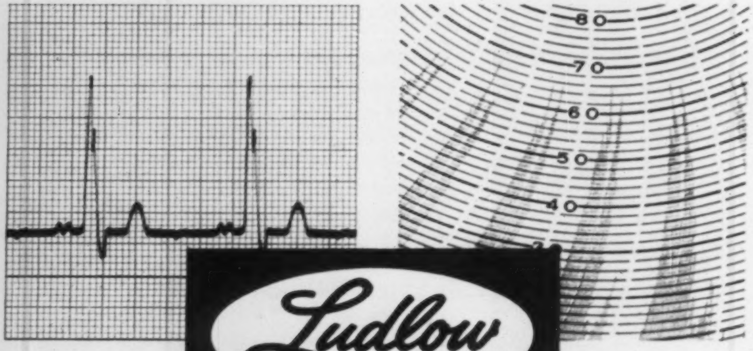
CIRCLE 85 ON READER-SERVICE CARD

for HEAT-Sensitive systems

for PRESSURE-Sensitive systems



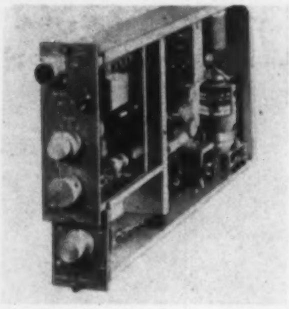
Ludlow

CUSTOM CHART PAPERS

You get the full potential from your recording systems when you use custom-made chart papers by Ludlow. Precision engineering assures constant fidelity. Write for free samples and literature or tell us your requirements. Ludlow Papers, Ware, Massachusetts, Dept. 162.

CIRCLE 86 ON READER-SERVICE CARD

DATA AMPLIFIER



New Type 491 Data Amplifier employs a circuit which inherently gives precise amplification, and features 0.01% gain stability, 0.01% linearity, and 10 v linear output. 8 amplifier modules, 2⅛" wide x 14½" deep, can be mounted in 8¾" of standard 19" rack space.—*Offner Electronics Inc., 3900 River Rd., Schiller Park, Ill.*

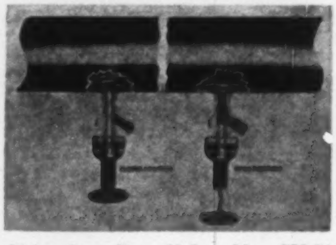
CIRCLE 184 ON READER-SERVICE CARD

COUNTER-TIMER

New Model 361-R 1-Mc Counter-Timer is an all-solid-state unit mounted on a standard 19" rack panel only 3½" high. Designated as an Apti-Meter, or actions-per-unit-time meter, it performs the following measurements: Totalizing random events over any of 8 time intervals from 10^{-6} to 10 sec, frequency from 0—10^6 pulses/sec or 1—10^6 cps, time interval from 10^{-6} to 10 sec, period from 10^{-6} to 10^7 seconds; frequency ratio; phase angle from 0—180°; pulse width; velocity; flow-rate; rpm.—*Transistor Specialties, Inc., Terminal Drive, Plainview, L. I., N. Y.*

CIRCLE 185 ON READER-SERVICE CARD

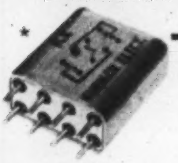
SAMPLING VALVE



New Sampling Valve No. SV-700 delivers perfect live samples, not affected by settlement or clogging owing to the s.-s. piston which, in closed position, completely fills the valve body and extends to inner surface of the vessel. Made with pipe threads, ¾" male inlet and ½" female discharge.—*Strahman Valves, Inc., Nicolet Ave., Florham Park, N. J.*

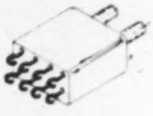
CIRCLE 186 ON READER-SERVICE CARD

Another KURMAN First! A COMPLETE LINE OF MICRO-MINIATURE RELAYS *'OFF-THE-SHELF'*

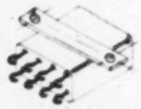


*

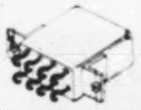
Case G



Case C



Case D



Case E

COMPETITIVELY PRICED

. . . available in prototype or production quantities from your nearby sales agency. Will fill most of your applications saving you time and money.

★SERIES KXI MICRO-MINIATURE

(.40 Max. x .875 x .80 Max.)

Equipped with special DPDT 2 amp contacts rated to carry any load from dry circuit to full rating. Features at 1/10" grid spaced header. Nominal operating power—250 milliwatts.

New torsional rotation balanced armature offers 20G 2,000 cycle vibration and 50G shock immunity. Proven reliability under all environmental conditions.

PLACE YOUR ORDER TODAY

RELAY NO.	CASE STYLE	HEADER	CONT. ARR.	CONTACT RATING (AMPS)	6, 12, 24 VDC Net (Quant. 1-10)†
KX1P2D	G	Plug-in	DPDT	2 amp	$15.95
KX1H2D	D	Solder	DPDT	2 amp	16.20
KX1H2C	C	Solder	DPDT	2 amp	16.20
KX1H2E	E	Solder	DPDT	2 amp	16.20

† For Discounts on larger quantities see Kurman Sales Agency or write to factory.

These leading Distributors — Kurman SALES AGENCIES — stock our complete line

EAST
Almo Radio Co., Philadelphia
American Electronics, Rochester
Arrow Electronics, Inc., Mineola
Cramer Electronics Inc., Boston
Hi-C Electronics, Inc., Rochester
Higgins & Sheer, Poughkeepsie
Lafayette Radio, Boston & New York
Mace Electronics, Erie, Pa
Milo Electronics Corp., New York
Quad Electronics, Inc., Brooklyn
Radio Equipment Corp., Buffalo
Schenectady Electronic Dist. Corp., Schenectady
Stack Electronics, Inc., Binghamton
Terminal Radio Corp., New York
Valley Electronic Labs, Inc., Utica
Wholesale Radio Parts Co., Baltimore

SOUTHEAST
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Forbes Electronic Distributors, Mobile
Freck Radio & Supply Co., Inc. Asheville, N.C.
Glenn Allen Co., Inc., Memphis, Tenn
Goddard Distributors, W. Palm Beach

MIDWEST
Industrial Electronic Supply of Grand Rapids, Grand Rapids
Interstate Supply Co., St. Louis
Pioneer Electronic Supply Co., Cleveland

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Midland Specialty Co., El Paso, Texas
Trice Wholesale Electronics, Oklahoma City

WEST
Avionic Supply, Culver City, California
Ballard Supply Co., Ogden
C & G Radio Supply, Seattle, Centralia, Tacoma, Bremerton, Olympia, Aberdeen
Dean Electronics, Long Beach, Calif
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See our catalog pages in the new Radio-Electronic MASTER

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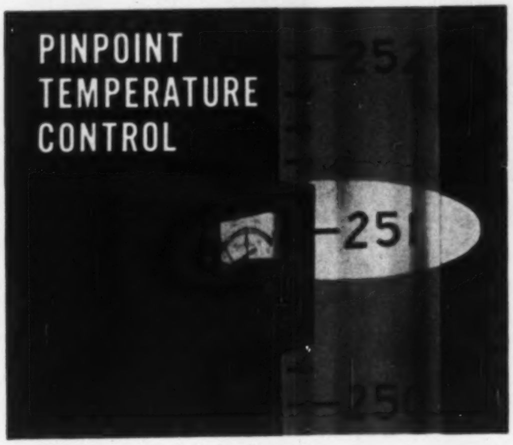
MASTER

KURMAN ELECTRIC CO.
Subsidiary of Crescent Petroleum Corp. • Quality Relays Since 1928
191 Newel St., Brooklyn 22, N. Y.
Export: 135 Liberty St., N.Y.C. Cable: TRILRUSH

CIRCLE 87 ON READER-SERVICE CARD



Temperature controlled by Simplytrol is kept within ± 1°F. of set-point. Simplytrol's special time-proportioning circuit *anticipates* temperature build-ups and *amount* of deviation from the control point. It modifies the heat cycle accordingly . . . before wide temperature fluctuations can occur.

Yet, this is a surprisingly simple device. No amplifying circuits. No vacuum tubes. The A.P.I. meter-relay—tested for more than ten-million operations, sensitive enough to work directly from a thermocouple—permits it to function with great precision, free of drift or distortion.

You'll find all Simplytrol models, in thirty ranges from —400°F. to 3000°F., described in Bulletin 108.

Write for your copy

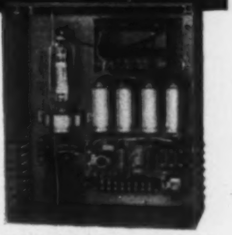
api **ASSEMBLY PRODUCTS INC.**
Chesterland 10, Ohio

CIRCLE 88 ON READER-SERVICE CARD

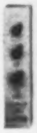
Electronically stops, starts, reverses!
Controls variable motor speeds!

New! HELLER C-60 ELECTRONIC CONTROLLER

with Separate Control Station Component and Matching ¾ h. p. Motor



Controller, in steel cabinet 14" wide x 16" high x 6" deep, is hot when outside switch is on. It operates a ¾ h.p. shunt wound motor on 220-230 volts, 50-60 cycles single phase.



Control Station Component has three simple controls for coarse or fine settings. Housed in a 2" x 2" x 9" steel box, the control station is connected to controller with a 10-foot 10-conductor vinyl jacketed cable.

Motor is ¾ h.p. at 2400 rpm with full torque from 300 rpm, ball bearing shunt wound with interpole, on frame J66-type DM by Master Electric Co. A 7-foot 4-conductor vinyl jacketed cable comes with motor. Motor and controller are operated from the control station.

C-60 CONTROLLER and CONTROL STATION
f.o.b. Las Vegas, Nev. **$240**
¾ H. P. MOTOR
f.o.b. Las Vegas, Nev. **$114**

Longer motor and controller cables supplied on order.

HELLER COP ELECTRONIC COMPONENTS
GERALD K. HELLER CO.
1819 Industrial Road Las Vegas Nevada

CIRCLE 89 ON READER-SERVICE CARD

inventive accomplishment in temperature sensing

from HARCO...

HARNESSES
complete line of standard parts and techniques to meet the exacting demands of modern thermocouple circuitry . . . standard or special applications. Bulletin 202.

CONNECTORS
accommodate greatest possible number of thermocouples in smallest space . . . yet have the mechanical strength and temperature resistance necessary to meet severe environmental conditions. Bulletin 185.

COMPLETE LINE OF METAL SHEATHED THERMOCOUPLES
especially for rapid, accurate, economical temperature sensing applications industry-wide. Accuracy of calibration well within recommended I.S.A. limits. Bulletin 161.

NEW CALIBRATION STAND
available in many models. Furnace design for acceptance of many different T/C configurations is available. Accuracy of readout within ±½°F. Bulletin 201.

NEW T/C REFERENCE JUNCTION COMPENSATOR
completely eliminates need for conventional ice bath as reference temperature source in thermocouple calibration. Several models, all with fifteen channels. Bulletin 201.

THERMOCOUPLE THERMOMETRY... PRECISION DEVICES FOR TEMPERATURE SENSING

All HARCO equipment . . . thermocouples, special potentiometers, pulse dividers, extension leads, pressure probes, and the devices shown above . . . is subjected to rigorous quality-control and inspection procedures to ensure performance accuracy and reliability, in application after countless application.

Because of today's rapid advances in both equipment and process development, the number of different temperature problems is increasing greatly . . . as is the close degree of accuracy and certainty required in their solution . . . and there is HARCO equipment to assist the solution of any such problem, however unique.

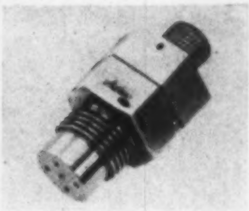
For further information on any HARCO product mentioned, write for specific literature, or ask for the name of the HARCO representative near you. If no standard HARCO device suits your special needs, we'll design a special one for you. Inquire.

HARCO LABORATORIES Inc.

DEPT. ICS • 77 OLIVE STREET • NEW HAVEN, CONNECTICUT

CIRCLE 90 ON READER-SERVICE CARD

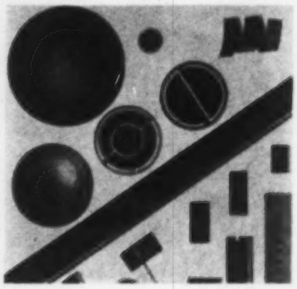
DAMPED TRANSDUCER



New Series 285 "damped" subminiature Absolute-Pressure Transducer features elimination of "ringing", and permits accurate measurements of pressure impulses with extremely short rise times. Pressure ranges available are from 50 psia to 5000 psia. With a 7v dc or ac excitation, nominal output for 1000 psi and below is 56 mv. For 1000 psi and above, output is 42 mc. Nonlinearity and hysteresis is less than ± 1% of full scale.—*Statham Instruments, Inc., 12401 Olympic Blvd., Los Angeles 64, Calif.*

CIRCLE 187 ON READER-SERVICE CARD

PHOTOELECTRIC CELLS



New Type 5 Photoelectric Cells, claimed to be more sensitive than previous cells, are available in almost any shape or size. Sizes of the selenium cells range as small as 1/16" square. Current sensitivity has been stepped up by 2, to 1 foot-candle, and potential sensitivity has been increased by 5, to 1 foot-candle over cells formerly available.—*Weston Instruments Div., Daystrom, Inc., 614 Frelinghuysen Ave., Newark 12, N. J.*

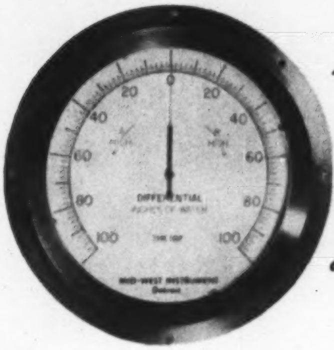
CIRCLE 188 ON READER-SERVICE CARD

WIRE-SPRING RELAY

New "wire-spring" Relay, Series WQA, designed to transfer up to 51 circuits quickly for 100 million or more operations without readjustment, incorporates a unique actuating card which is activated by armature movement and operates all moving wire-spring contacts simultaneously and independently. Available in one, two, or three levels of contact assemblies, with up to 17 Form-C combinations, each. Operating voltages range from 6 to 220 dc. Rectified ac is also accommodated.—*Automatic Electric Labs., Northlake, Ill.*

CIRCLE 189 ON READER-SERVICE CARD

DIFFERENTIAL GAUGES



A rugged, dependable instrument to fit your applications

MID–WEST DIFFERENTIAL INSTRUMENTS OFFER:

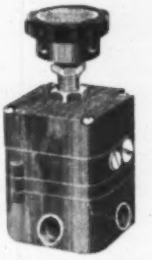
☆ 4000 PSI WORKING PRESSURE
☆ FULL OVERRANGE PROTECTION
☆ 100 INCHES OF WATER TO 400 PSID
☆ STANDARD & PRECISION MODELS

SPECIAL DESIGNS MADE TO ORDER

MID–WEST INSTRUMENT DIV.
ASTRA ASSOCIATES INC., 1021 E. STATE FAIR
DETROIT 3, MICHIGAN

CIRCLE 91 ON READER-SERVICE CARD

WORLD'S MOST ACCURATE AIR-PRESSURE REGULATOR



- **Holds pressure to 1/5 of 1/10 of 1% of its range over substantial variations in supply pressure, flow, and ambient temperature. Resolution: 1 part in 10,000 of range.**
- **No exhaust-valve "pick-up" or initial drop-off on dead-end service. No drift with time or periodic shutdown.**
- **Designed for rugged service and minimum maintenance.**
- **50,000 user-tested for 6 years. Accepted as *primary standard of reference.***

You can prove it! This new air pressure regulator is the world's most accurate and reliable device for precise control of air or gas pressure. Yet it costs no more than other pilot-operated regulators.

Key to its unequalled accuracy and instant response is its patented high-gain servo design, which uses regulated rather than supply pressure, and its stainless steel pressure capsule

Available in 2-25, 3-60, or 3-120 psi ranges for ⅛", ¼", or ⅜" NPT pipe at 15 U.S. stocking points. Standard trade and quantity discounts. *Write now for data sheet and prices.*

Some territories are still open for qualified technical sales representatives.

Lexington Controls
INCORPORATED®
P. O. BOX 132-D BURLINGTON, MASS.
PROTECTED BY U.S. AND FOREIGN PATENTS AND PATENTS PENDING.

CIRCLE 92 ON READER-SERVICE CARD

Investigate the *Dillon* Stainless Steel Thermometer

150
200
Dillon
100
250
50
300

- 12 Fah & Cen ranges for gases or liquids
- 1", $1\frac{11}{16}$", $2\frac{5}{16}$", 3", 5" head sizes
- Stem lengths from 2½" to 72"
- Straight form or angle form
- Choice of mounting nuts
- Pressure & moisture proof. Overheat protected.
- Corrosion resistant (bezels & stems made of 316 ss)
- Exclusive bi-metal coil, individual calibration insure utmost accuracy
- Screw-in or surface float
- Special models & ranges to order

YOURS FREE! Engineering catalog describing more than 100 models of Dillon Thermometers and quoting prices. Write today!

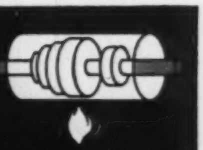
W. C. *Dillon* & COMPANY, INC.

14584 Keswick St.,
Van Nuys 13, Calif.

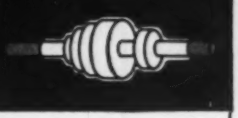
T-42

CIRCLE 93 ON READER-SERVICE CARD

EXPANDED TEFLON TUBING



THAT SHRINKS TO FORM A TIGHT FIT!



IT IS USED:

To encase irregular shapes
To protect electrical components
To obtain tight fits over rollers and machined parts
To join chemical tubes and metal fittings, etc.

PF Teflon-TFE tubing, which has been expanded mechanically, will recover the original dimensions promptly and clamp tightly to the inserted object when heat is applied. This new PF tubing:

- retains the outstanding electrical, mechanical and chemical properties of Teflon
- is available in all popular sizes, in both thin and standard walls, in 11 basic colors, printed and cut to the lengths you require
- can be made cementable

This new Teflon tubing will fit your critical requirements. Get complete details today. Write, wire or call.

PENNSYLVANIA FLUOROCARBON CO., INC.
1115 N. 38TH STREET, PHILADELPHIA 4, PA.
PHONE: EVergreen 6-0603 TWX: PH 252

*Du Pont Reg. T.M.

CIRCLE 94 ON READER-SERVICE CARD

Uniflow Springless type 500 air to open – air to close – 1/2" to 12" pneumatic or electro pneumatic

with positioner
without positioner

Uniflow

gives you TWO in ONE...

- **QUALITY**
- **PERFORMANCE**

In chemical, slurry, water treating and high vacuum installations, UNIFLOW Valves are fast becoming the most popular because not only are they low in cost, but highest quality requirements are met and maintained.

Uniflow Air Operated Control Valves employ Saunders patent valve features—the valve that requires no stuffing box or stem packing.

Why not learn how you can fill your difficult control valve needs quickly—economically.

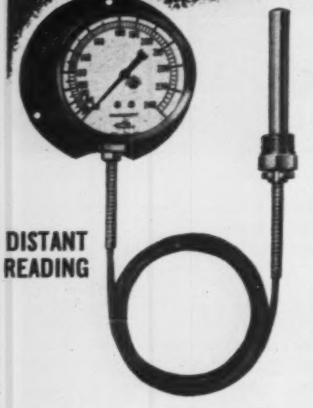
WRITE FOR
BULLETIN 114R

Uniflow
Valve Corporation
20 QUINE ST., CRANFORD, N. J. • BR 6-8300

UVC

CIRCLE 95 ON READER-SERVICE CARD

There's a MARSH *thermometer for every need*



the
dial thermometer
at its best

In the Marsh Dial Thermometer you have the best type—the bourdon tube type—in its highest development. These are instruments made in the Marsh manner—instruments that embody the recognized precision and accuracy of Marsh Pressure Gauges.

Both vapor-tension and gas-filled types are available in the broad Marsh line...a type, size, case-style, finish and temperature range to solve practically any dial thermometer problem.

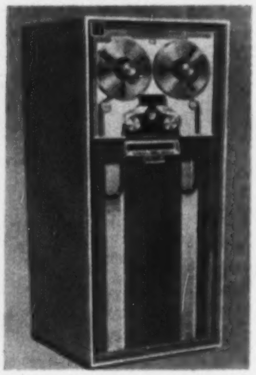
Ask for the Thermometer Catalog

MARSH

MARSH INSTRUMENT COMPANY, Dept. 42, Skokie, Ill.
Division of Colorado Oil & Gas Corporation
Marsh Instrument & Valve Co., (Canada) Ltd.
8407 103rd St., Edmonton, Alberta, Canada
Houston Branch Plant, 1121 Rothwell St.
Sect. 15, Houston, Texas

CIRCLE 96 ON READER-SERVICE CARD

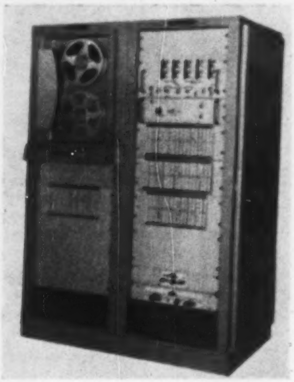
TAPE TRANSPORT SYSTEM



New Digital Tape Instrument incorporates a new concept in digital Tape Transport Systems (Model M-3000), which materially accelerates the handling and storage of data on magnetic tape. Use of linear-action electropneumatic reeling and tape drive system provides gentle, yet positive tape handling. This, along with the elimination of reciprocating parts subject to impact, avoids wear on both the machine and tape.—*Midwestern Instruments, Tulsa, Okla.*

CIRCLE 190 ON READER-SERVICE CARD

SOLID-STATE MODULES FOR DIGITAL SYSTEMS



New solid-state Modules, using standard logic circuitry and performing a specific function, allow digital systems to be assembled to multiplex and digitize data at rates up to 15,000 samples/sec within an accuracy of 0.5%. By use of the modules in various arrangements these functions can be performed: magnetic tape system record and playback electronics, high- and low-level multiplexing, analog-to-digital and digital-to-analog conversion, format conversion, editing and transcribing, and tape-to-card and card-to-tape conversion. Each module is of the same size and is plugged into its own pin-connected receptacles.—*Minneapolis-Honeywell Regulator Co., Industrial Systems Div., Beltsville, Md.*

CIRCLE 191 ON READER-SERVICE CARD

ACCURATE TEMPERATURE READINGS

From -40°F to 200°F in 3 to 5 seconds

Alnor

PYROMETER

Price $160.00

without thermocouple tip

Model 2300B

The following thermocouple tips are available at $35.00 each. Surface reading—air temperature—hypodermic needle—rigid immersion—needle and flexible wire type thermocouples.

This direct reading instrument has a full 6" mirrored dial of exact calibration. The movement is built with unusual precision, has jewel bearings and the very finest workmanship.

Each thermocouple is carefully constructed to obtain the exact circuit resistance; its calibration checked for resistance and also checked against known temperatures. Production is quality controlled within very fine tolerances to match the precision of the indicator movement. Bulletin 2146C contains detailed specifications.

Alnor INSTRUMENTS

ILLINOIS TESTING LABORATORIES, *Inc.*
Room 518, 420 N. LaSalle St., Chicago 10, Ill.

CIRCLE 97 ON READER-SERVICE CARD

GREEN PANTOGRAPH ENGRAVERS

- ELIMINATE DELAYS!
- KEEP YOUR OPERATING COSTS WHERE THEY SHOULD BE!

PORTABLE 40-POUND BENCH MODEL 106

Here is a speedy, economical 2 or 3-dimensional engraver used by thousands of dollar-conscious companies. It features 5 positive, accurate pantographic ratios; ball bearing spindle with 3 speeds up to 14,000 rpm. Is supplied with one copy carrier that accepts all standard master type sizes. Will actually work up to 10" by any width. Height of pantograph and position of cutter are continuously adjustable.

You Make Your Own Engraved Nameplates!

MODEL D-2 HEAVY-DUTY 2-DIMENSIONAL

Pantograph for milling, drilling and engraving.

Vertical adjustment of copy table automatic with Pantograph. Features: unobstructed on 3 sides to take large work; micrometer adjustment for depth of cut; ball bearing construction throughout; spindle speeds up to 26,000 rpm for engraving or machining; vertical range over 10"; ratios 2 to 1 to infinity — master copy area 26" x 10"

NEW

MODEL D2-201 PNEUMATIC ATTACHMENT

for use with Model D2 Pantograph Engraver to rapidly drill holes in printed circuits by tracing templates. Drills as many as 100 holes per minute. Equipped with foot switch; spindle air cylinder; regulating valve and pressure gauge; filter and oiler. It's ready to use as soon as it's attached to an air compressor

Write or call for full details and prices.

GREEN INSTRUMENT COMPANY, INC.
Dept. 66, 295 Vassar St.
Cambridge 39, Mass. Tel. Eliot 4-2989

CIRCLE 98 ON READER-SERVICE CARD

FREE ENGINEER'S FACT FILE

A Complete Manual on

MERCURY PLUNGER RELAYS

For all loads up to 60 Amps or 5 H.P.

EBERT ELECTRONICS CORP.

Single Pole

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Triple Pole

FREE: Brand new edition, fully illustrated. Rated as the standard reference manual on all types and applications of Mercury Plunger Relays. 1, 2 and 3 pole hermetically sealed, compact and miniature units that provide millions of continuous makes and breaks without maintenance. No pitting or corrosion.

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CIRCLE 99 ON READER-SERVICE CARD

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A LIST OF MATERIALS WE FABRICATE USED IN OPTICS AND ELECTRONICS

SAWING GRINDING POLISHING DRILLING

ALUM
ALUMINA
ALUMINUM
ANTHRACENE
ARSENIC TRISULPHIDE
BARIUM TITANATE
BISMUTH
BRASS
CARBORUNDUM
CERAMIC
COBALT FERRITE
COPPER
*CORNING 707
*CORNING 7052
COPROUS BROMIDE
FERRITE
FERROX
**FLUORIDE, CALCIUM
**FLUORIDE, LITHIUM
GALLIUM ANTIMONIDE
GALLIUM ARSENIDE
GARNET
GERMANIUM
GOLD
INDIUM ANTIMONITE
INDIUM PHOSPHIDE
INDOX
IRON SINGLE CRYSTAL
LITHIUM
MAGNETIC PLUMBITE
MELAMINE FIBER GLASS
MICA, SYNTHETIC
NICKEL OXIDE
PLATINUM
POTASSIUM BROMIDE
*PYREX
*QUARTZ, CRYSTAL
*QUARTZ, FUSED
**SAPPHIRE
**SODIUM CHLORIDE
**STEEL
STRONTIUM TITANATE
TEFLON
TITANIUM DIOXIDE
*VYCOR
*X-RAY LEAD GLASS
ALL TYPES KNOWN GLASS

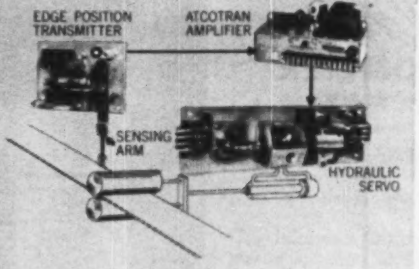
* Carried in stock
** Purchased for orders

CIRCLE 100 ON READER-SERVICE CARD

DISPLACEMENT PICK-UPS FOR MACHINE AUTOMATION

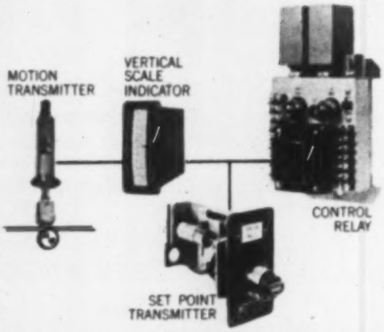
EDGE CONTROL

Atcotran Edge Guide Control maintains constant, precise edge positioning (within 0.001") for accurate register of moving web. Range is 2¼" with only ¼ oz. pressure on edge. Stable null balance circuit. For paper, metals, textiles, plastics, etc.



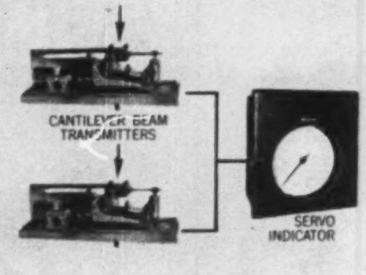
THICKNESS MEASUREMENT

ATC measuring devices for reliable automation control systems. Indicates and controls thickness to adjustable pre-set tolerance. Ideal for wallboard, sheet metal, plywood, plate glass, etc.



WEIGHT SUMMATION

ATC Cantilever Load Cells change force (or weight) to electrical signal, recorded as weight on servo indicator. Multiple load cells may be algebraically coupled for indication-control of force, thrust, torque, etc.



ADVANCED DIFFERENTIAL TRANSFORMER PRINCIPLE permits simple and rapid automation of machine functions using standard off-the-shelf control components, indicators, recorders, and process controllers. Discuss your applications and requirements with your ATC representative.

Send for literature on Atcotran Differential Transformer Experimental Kit—today!

atc

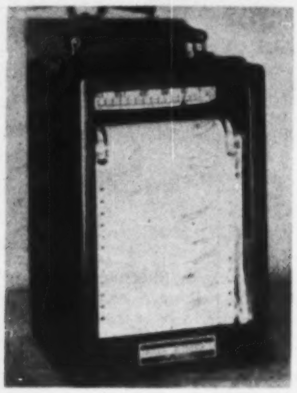
AUTOMATIC TIMING & CONTROLS, INC.
KING OF PRUSSIA, PENNSYLVANIA
A Subsidiary of American Manufacturing Company, Inc.

ATC, Div. of Interprovincial Safety Industries, Ltd., 5485 Notre Dame St., West, Montreal 30, Quebec

CIRCLE 101 ON READER-SERVICE CARD

ICS NEW INSTRUMENTS

RECORDING VOLTMETER



New transient-sensitive Recording A-c Voltmeter records voltage values in ink on moving graph paper (for steady state voltages a straight line is drawn). Variations or transients as small as 2 v, with durations of less than 32 msec can be recorded. Possible uses for the instrument include monitoring of regulated voltage supplies on computers and other electronic apparatus. Scaled from 0 to 150 v 60 cps, in linear divisions. Available in a wide variety of cases and chart drive combinations.—*Esterline-Angus Co., Box 596, Indianapolis 6, Ind.*

CIRCLE 192 ON READER-SERVICE CARD

REMOTE CONTROL SYSTEM

alpha tech
alpha tech

New portable radio-transmitter-and-receiver Control System operating in the examination-free 27-Mc Citizens Band, works on the tone-modulated carrier principle. Keying the transmitter actuates SPDT relay at receiver. Control may be either simple on-off, or pulsed as required through convenient pulsing receptacle. Range is up to one mile.—*Alpha Tech Products, Box 111, Appleton, Wis.*

CIRCLE 193 ON READER-SERVICE CARD

TYPE **JK**
ROTARY SWITCH
manufactured in
accordance with
MIL-S-21604
and BuShips
Drawing Number
815-1853013.

Sections and rotors
molded of
MAI-60 per MIL-M-14E.

ESCO Type JK rotary switch provides unlimited rotation in both directions.

Movement can be limited to any number of 16 positions.

Electrical rating: up to 5 amperes,
125 volts a-c.
Write for Bulletin No. 19

ESCO of WEYMOUTH
ELECTRO SWITCH CORP.
Weymouth (Boston 88), Massachusetts

CIRCLE 102 ON READER-SERVICE CARD

TYLOK
TUBE COUPLINGS

"TYLOK" 4 Seal Coupling design is the most complete answer to difficult tube problems on the market today.
"TYLOK" couplings will hold against all pressures, temperatures, vibrations and surge beyond the rupture yield point of any tubing, regardless of material or wall thickness . . . including all brands of plastic tubing.
There is a "TYLOK" tube coupling to meet your needs, write, wire or phone for further information and catalog.

C. B. CRAWFORD COMPANY
16606 Waterloo Road, Cleveland 10, Ohio

CIRCLE 103 ON READER-SERVICE CARD

a guide

to equipment sources and selection

Instruments and Control Systems annual *Buyers' Guide* lists control equipment, systems, & components available from more than 3,000 manufacturers.

Subscribe now to *Instruments and Control Systems* (formerly *Instruments & Automation*) and receive, without extra charge, your personal copy of the only buying directory serving the instrument-control field. The *Guide* is issued each year (to subscribers only) as 300-page separately bound part 2 of October *Instruments and Control Systems.*

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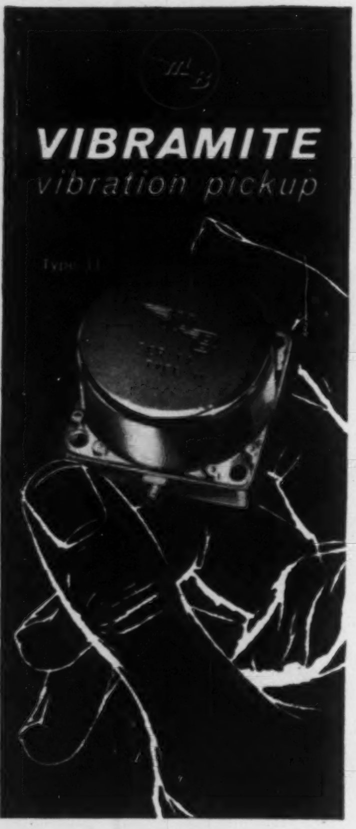
Principal Product of Your Plant ______

($4-per-year rate for U. S., U. S. Possessions, and Canada, only.)



sensitive . . .
yet rugged
damped...*yet with*
flat response

In fact, the new Vibramite pickup is the only available damped unit with a flat response curve over its entire operating range.

It is also small in size, light in weight . . . and can be mounted in any desired position without adjustment.

Check these specifications:

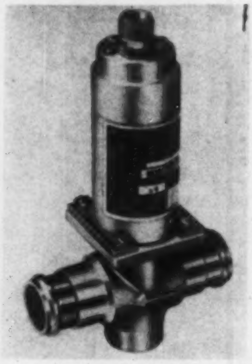
Frequency range	20-2000 cps
Sensitivity	96.3 mv/in/sec. (Calibrated ±1% at 100 cps into 2 megohm load at 80°F)
Size	1" x 1.42"
Weight	2.75 oz
Natural frequency	15 cps
Damping	Eddy current (nominal .65 of critical)
Acceleration output limit	50 g maximum (minimum limited only by recording equipment)
Max. shock without damage	1000 g

Complete technical details in Bulletin 112A. Write . . .

MB ELECTRONICS

A DIVISION OF TEXTRON ELECTRONICS, INC.
1061 State Street, New Haven 11, Conn.
CIRCLE 104 ON READER-SERVICE CARD

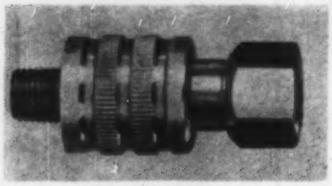
SOLENOID VALVE



New direct-acting venturi-type Solenoid Valve, Ucodel V-20000-04 Shut-Off, of 1" line size weighs only 1¾ lb. Only high temperature insulating materials are used: Teflon, silicone, and glass. The coils are unaffected by mechanical and thermal shock, and maintain dielectric strength under salt spray, temperatures to 500°F, and other adverse environmental conditions.—*Valcor gineering Corp., Kenilworth, N. J.*

CIRCLE 194 ON READER-SERVICE CARD

SLEEVE VALVE



New 3-way, 2-position air-control Sleeve Valve for on-off operation is made of top quality, corrosion-resistant materials. Eight air-passage holes allow the valve to operate close to full capacity with very low friction loss.—*Airmatic Valve, Inc.,* 7313 *Associate Ave., Cleveland* 9, *Ohio.*

CIRCLE 195 ON READER-SERVICE CARD

FREQUENCY METERS

FREQUENCY
CPS

New expanded-scale Frequency Meters for highly accurate measurement of 400- and 60-cps power frequencies provide an exceptional degree of reliability and readability. Accuracy of frequency indication is 0.1%. Details in Bulletin F-06.—*Airpax Electronics Inc., Seminole Div., Fort Lauderdale, Fla.*

CIRCLE 196 ON READER-SERVICE CARD

THE NEW M200
MICRO-MINIATURE
RELAY!
ACTUAL SIZE

For wide INDUSTRIAL and MILITARY APPLICATIONS!

Features:

- ✓ .200 Grid, Crystal Can
- ✓ Non-latching DC, 2PDT
- ✓ 2 Ampere Contacts
- ✓ Hermetically Sealed
- ✓ General Purpose, Dual Coil

Here is the NEW U.S. Relay-Electronics general purpose Micro-Miniature M200 Relay Series—interchangeable with all similar units, regardless of manufacturer!

The M200 Series surpasses all test requirements! Units were tested at 750 volts RMS between open contacts—Maximum contact bounce of 1.5 milliseconds—operating and release time, 4 milliseconds and Grade 4 vibration tests in 3 mutually perpendicular axes at .200" double amplitude from 10 to 55 cps and shock of 30 G's from 55 to 3000 cps. Meets MIL-R-25018.

The M200 Series is engineered for use in: computers; special small sub-systems for applications with aircraft and missiles; data processing equipment; airborne and missile check-out equipment; automation equipment; and communications equipment.. M200 versatility is unmatched for any application—INDUSTRIAL or MILITARY!

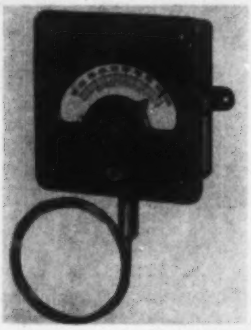
For further information and certified test reports on the M200 Series, write to:

USRE

Leading the art with
quality Relays.

U. S. RELAY-ELECTRONICS
a division of A-S-R Products Company
717 North Coney Avenue, Azusa, California
CIRCLE 105 ON READER-SERVICE CARD

TEMPERATURE CONTROLLER



New compact, remote-bulb, high-temperature indicating Temperature Controller, Type E36N, combines accuracy and sensitivity over wide ranges (100 to 1000°F). Three models, featuring three sensing bulb styles, are offered. Several switch actions are available including NC, NO, and DT. All snap-action switches are SP and suitable for up to 180°F ambient temperatures.—*United Electric Controls Co., 85 School St., Watertown, Mass.*

CIRCLE 197 ON READER-SERVICE CARD

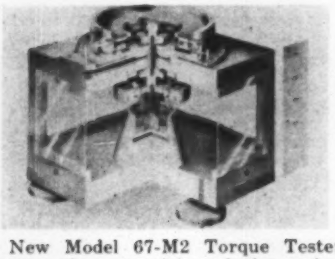
DIGITAL LOGIC BLOCKS

DIGIPAC
DYNAMIC CONTROLS COMPANY

New Digipac line of miniature logic blocks includes flip-flop, clock, delay, inverter, gate, pulse amplifier, and indicator. Circuits operate with wide margins at speeds up to one Mc, and are intended for use in permanent and semi-permanent control systems.—*Dynamic Controls Co., 2225 Massachusetts Ave., Cambridge, Mass.*

CIRCLE 198 ON READER-SERVICE CARD

TORQUE TESTER



New Model 67-M2 Torque Tester is an ultra precision device using air bearings. Measurements are accomplished by summing torque about the air-supported shaft. Spec sheet gives details.—*Dynamics Research Corp., 38 Montvale Ave., Stoneham, Mass.*

CIRCLE 199 ON READER-SERVICE CARD

Model 791D

$920

DEVIATION MEASURED

10cps to 125kc

New FM Deviation Meter has carrier frequency range 4—1024Mc; crystal controlled LO enables measurement down to 10cps deviation. Used with a 'scope, it measures peak deviation of complex wave forms. Very easy to operate, Model 791D ***speeds*** deviation measurements.

●

Carrier Freq. Range: 4—1024Mc, xtal locked
Mod. Freq. Range: 25cps to 35kc
Deviation Ranges: 0-5, 25, 75, 125kc.
Accuracy: 3%. Xtal standardized
Distortion: Less than 0.2%
21 tubes: 6AK5, 6C4, 0B2, 5651, 6CD6G, 5Z4G, 5647, 6AS6

MARCONI INSTRUMENTS
111 CEDAR LANE • ENGLEWOOD, NEW JERSEY

CIRCLE 106 ON READER-SERVICE CARD

NEW! Meter Recorder Marking System with a Slip-In Cartridge!

Esterbrook's *customized* marking systems guarantee you complete satisfaction . . . for *any* type recorder . . . Circular . . . Strip . . . Miniature *or* Plotter!

Customized for your meter recorder by Esterbrook

Give your customers the benefit of *ink cartridge convenience*, and a century of experience in the recording product you build. . . . Now—Esterbrook's Technical Products and Instrument Division will custom-design and build a new marking system for *your* product.

The result: no more breaking down . . . no more hand fixing! With Esterbrook's new *customized* meter recorder you'll conserve operating time . . . *and* you'll receive the free design time and engineering assistance of experts!

For further information write to:
Technical Products & Instrument Division
The Esterbrook Pen Co. • Camden 1, N. J.

TECHNICAL PRODUCTS AND INSTRUMENT DIVISION
The Esterbrook Pen Company
CAMDEN 1, NEW JERSEY

CIRCLE 107 ON READER-SERVICE CARD

Dwyer
CONTROLS GAGES

AIR VELOCITY METER
No. 400

One Instrument Tells Both Air Velocity and Static Pressure!

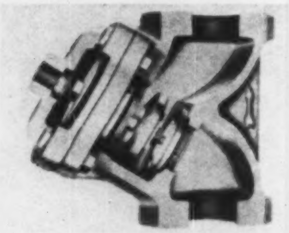
- Reads directly in feet per minute and inches of water.
- Check *all* velocities from 400 to 10,000 F.P.M.
- All static pressures from 0 to 10" of water.

Tests fan and blower discharge and inlet pressures, pressure drop across filters, balances air conditioning systems, etc. Complete kit includes dual purpose manometer, 18" stainless steel pitot tube, Magne-clip mounting panel and all necessary fittings, tubings, instructions and accessories.

Write today for literature and prices.

F. W. DWYER MFG. CO.
P. O. Box 373-S Michigan City, Ind.
CIRCLE 108 ON READER-SERVICE CARD

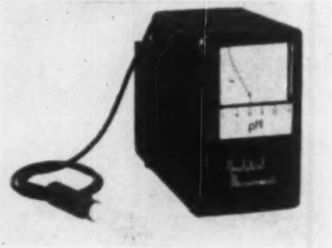
DIAPHRAGM VALVES



New line of Diaphragm Valves features a simple and reliable diaphragm actuator, working directly off the actual line pressure. Three groups are available: Series 421 in ¾" and 1" sizes, Series 424 in 1¼" and 1½" sizes, and Series 426 in 2" and 2½" sizes. Diaphragm is of neoprene, reinforced with nylon. Low pressure-loss is obtained by minimum obstruction and deviation of the flow through the valve. Bulletin 800 gives details.—*AquaMatic, Inc.,* 2412 *Grant Ave., Rockford, Ill.*

CIRCLE 200 ON READER-SERVICE CARD

RECORDING pH METER



New Analytical Recording pH Meter combines a pH meter and strip-chart recorder which uses pressure-sensitive coating on the chart paper. Connections for insertion of a platinum resistance thermometer provides automatic temperature compensation. A switch on the front panel permits disconnection of the chart drive so that the instrument becomes an indicating pH meter.—*Analytical Measurements, Inc.,* 585 *Main St., Chatham, N. J.*

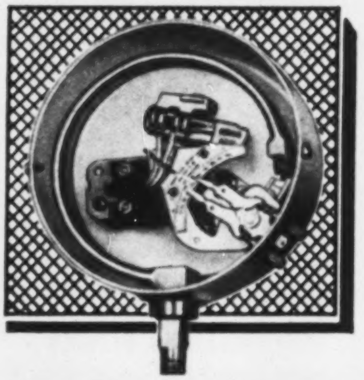
CIRCLE 201 ON READER-SERVICE CARD

LINT-FREE COVERALL

New lint-free, static-free, acid-resistant Coverall featuring streamline pattern for plant safety, is made of white herringbone Dacura, a blend of polyester fiber and rayon. Details in six-page folder.—*Angelica Uniform Co.,* 1427 *Olive St., St. Louis* 3, *Mo.*

CIRCLE 202 ON READER-SERVICE CARD

A NEW ADDITION to MERCOID PRESSURE CONTROLS



316 STAINLESS STEEL
Welded Bourdon Tube and Pressure Connection

Series D-41, 243, 541

316 stainless steel welded Bourdon tube. ¼" (316) stainless steel pressure connection. Nickel plated mechanism. Outside adjustments. Calibrated dial. Hermetically sealed mercury contact.

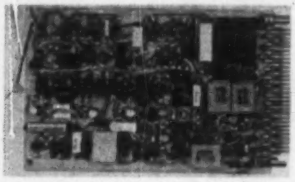
Operating ranges: 30" vac.-75 psig; 10-100 psig; 30-400 psig; 75-800 psig. and 100-1000 psig.—with varying differentials and electrical capacity to meet your application.

Three case styles: General Purpose NEMA 1; Weather-Proof NEMA 1A, 2, 3, 4; Explosion-Proof Class 1 Group C, & D; Class 2 Group E, F, G, NEMA 7, 9, 9A.

WRITE FOR BULLETIN 019

THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill
CIRCLE 109 ON READER-SERVICE CARD

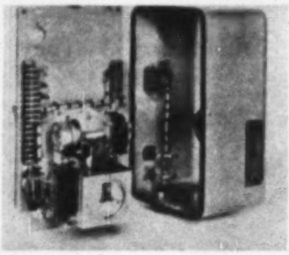
SAMPLE AND HOLD MODULE



New fast Sample and Hold Module Model SA 1, which samples rapidly moving wave forms and holds the sampled values long enough to be converted to digital form in the Adage Voldicon, is functionally equivalent to an input operational amplifier connected through a switch to an RC filter followed by a low impedance output amplifier. It can be incorporated as an accessory in any of the basic Voldicons.—*Adage Inc.*, 292 *Main St., Cambridge* 42, *Mass.*

CIRCLE 203 ON READER-SERVICE CARD

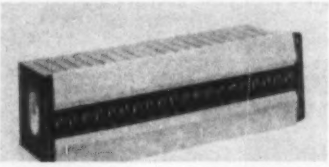
SWEEP BALANCE BTU METER



New Sweep Balance BTU Meter accurately assesses heating or cooling costs on the basis of recorded consumption. Employing electrical-resistance thermometers and a unique electromechanical computing device, it requires no amplifiers. Turbine-type flow meters make possible high counting accuracy over the full range of flow rate. Average time error is not more than 0.1 sec, or the equivalent of 0.2% of the maximum temperature difference measured.—*Air Conditioning Equipment Corp.*, 219 *E. 44th St., New York* 17, *N. Y.*

IRCLE 204 ON READER-SERVICE CARD

DIGITAL SWITCH



New 16-position dial-setting Switch, Series 7320 Digiswitch, has 16 single-pole switching positions plus an off position. Features include in-line visual read-out, positive finger-detent operation, and modular construction with savings in panel space. Optional are color-coding of decades, internal lighting, and special dial characters. —*Digitran Co.*, 660 *So. Arroyo Parkway, Pasadena, Calif.*

CIRCLE 205 ON READER-SERVICE CARD

DON'T WAIT TILL IT'S TOO LATE!

ASSURE SYSTEM DEPENDABILITY

WITH **TRINITY THERMOWELLS**

Trinity Thermowells fit right, work right and last longer. Made of certified materials to the most exacting tolerances in the industry, Trinity Thermowells are backed by a written guarantee accompanying each standard well.

WITH **TRINITY THERMOCOUPLES**

A complete selection of wire materials and sizes, welded to meet or exceed the industry's standards assure you accurate performance in every installation when you select a Trinity Thermocouple.

WITH **TRINITY TRINOX**

Precise thermocouple assemblies sheathed in a protective well for miniaturized, or hard-to-reach points in a system or assembly. Also available in multi-point assemblies. Trinox is available in sizes down to .040" in diameter.

Start with the best, or replace with the best—to maintain top dependability in your system. No system is more dependable than any single component in it—and when it comes to thermowells or thermocouples, you're guaranteed the finest with Trinity...

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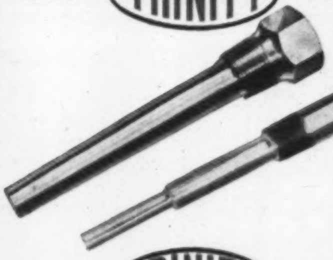
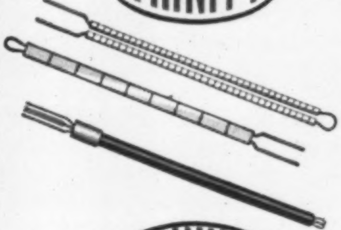
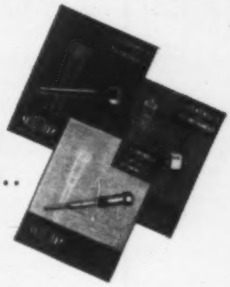
Thermocouples and Thermowells

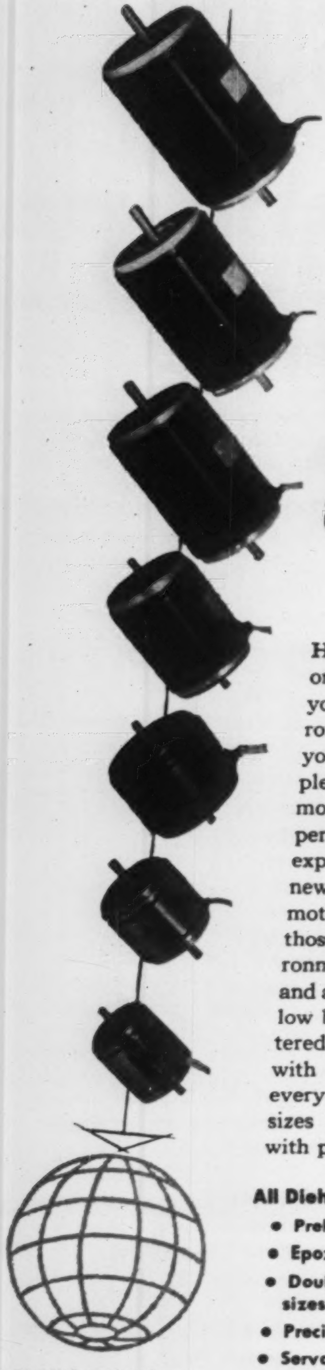
TRINITY EQUIPMENT CORPORATION, CORTLAND, NEW YORK

CIRCLE 110 ON READER-SERVICE CARD









let's get down to earth about servomotors

Has space exploration caused your servomotor cost to skyrocket? . . . forcing you to pay for protection against environments found only in space . . . not in your applications? If so, the now complete line of DIEHL Instrument Servomotors that give "out of this world" performance at down to earth prices is expressly tuned to your needs. These new epoxy encapsulated, round frame motors were especially designed for those applications where earthly environments such as salt, fungus, moisture, and ambients of —55 to + 55°C... (and low budgets) . . . are normally encountered. And, the line has been developed with sufficient latitude to meet your every rating requirement. Available in sizes 11 and 15, and in larger frames with power outputs from 1 to 20 watts.

All Diehl Instrument Servomotors feature:

- Prelubricated ball bearings
- Epoxy encapsulated windings
- Double shaft extension (pinioned for sizes 11 and 15)
- Precision machined aluminum housing
- Servo mount
- Optional addition of integral tachometer or precision gear train.

A World of servo engineering... for the servo engineering world... The versatile Diehl family of Servo Components.

If you have an earthbound application,
why not get the servomotor fitted to your needs?
For more information, write to

Diehl†
DIEHL MANUFACTURING COMPANY
A SUBSIDIARY OF THE SINGER MANUFACTURING COMPANY
Somerville, New Jersey
SINGER*

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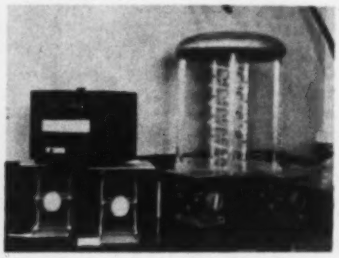
CIRCLE 111 ON READER-SERVICE CARD

CORONA DISCHARGE DETECTOR

New System which detects and displays on an oscilloscope any trace of corona; whether caused by voids within an insulating structure, insufficient clearances, or other defects in material or completed assemblies; is a high-gain, wide-band amplifier which feeds a high-sensitivity oscilloscope.—*Associated Research, Inc., 3777 W. Belmont Ave., Chicago 18, Ill.*

CIRCLE 206 ON READER-SERVICE CARD

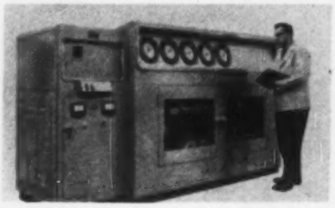
SHIELDED RESISTOR



New 100-megohm shielded Resistor is similar to that developed by the National Bureau of Standards. The divider is made up of 100 one-megohm wirewound resistors. Each resistor is located concentrically within a shield which is at the potential of one terminal of the resistor.—*AVCO Research and Advanced Development Div., 201 Lowell St., Wilmington, Mass.*

CIRCLE 207 ON READER-SERVICE CARD

URANIUM ISOTOPE ANALYZER



New Analyzer, a modified emission spectrometer, makes possible quick, convenient analysis of uranium isotopes U-235, U-236, and U-238 by using an automatic optical servo monitor in the Spectromet model, in combination with a special diffraction grating and a three-prism beam-splitter.—*Baird-Atomic, Inc., 33 University Rd., Cambridge 38, Mass.*

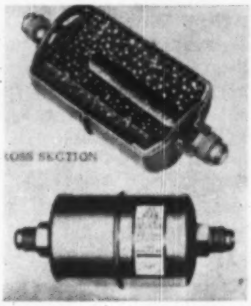
CIRCLE 208 ON READER-SERVICE CARD

DIGITAL BUILDING BLOCKS

Four new 10-Mc Building Blocks include flip-flop Type 1202, and clock Type 1403, which become part of DEC's expanded line of system building block plug-in units. Flip-flop Type 202 and clock Type 403 are patchcord-interconnecting digital test equipment units. The flip-flops have built-in amplifiers, indicator, source of counting carry pulses, complement input, and two transistor gates.—*Digital Equipment Corp., Maynard, Mass.*

CIRCLE 209 ON READER-SERVICE CARD

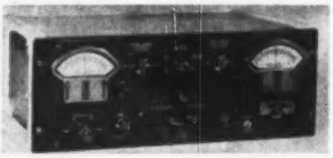
FILTER-DRYER



New block-type Filter-Dryer, Dri-Kleaner, combining silica gel P.A. 400 and Molecular Sieve desiccants, bonded in rigid form, adsorbs acids and colors, making it possible to easily meet the ASRE-ARI Standards.—*Alco Valve Co.,* 865 *Kingsland Ave., St. Louis* 30, *Mo.*

CIRCLE 210 ON READER-SERVICE CARD

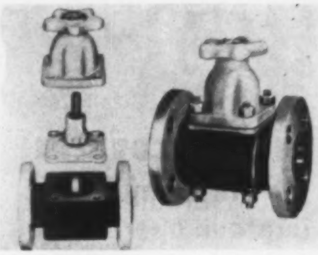
IMPEDANCE COMPARATOR



New version Impedance Comparator, Type 1605-AS2, compares a resistor, capacitor or inductor with a standard sample, indicating directly on panel meters the magnitude and deviation of impedance difference and phase-angle difference between them.—*General Radio Co., West Concord, Mass.*

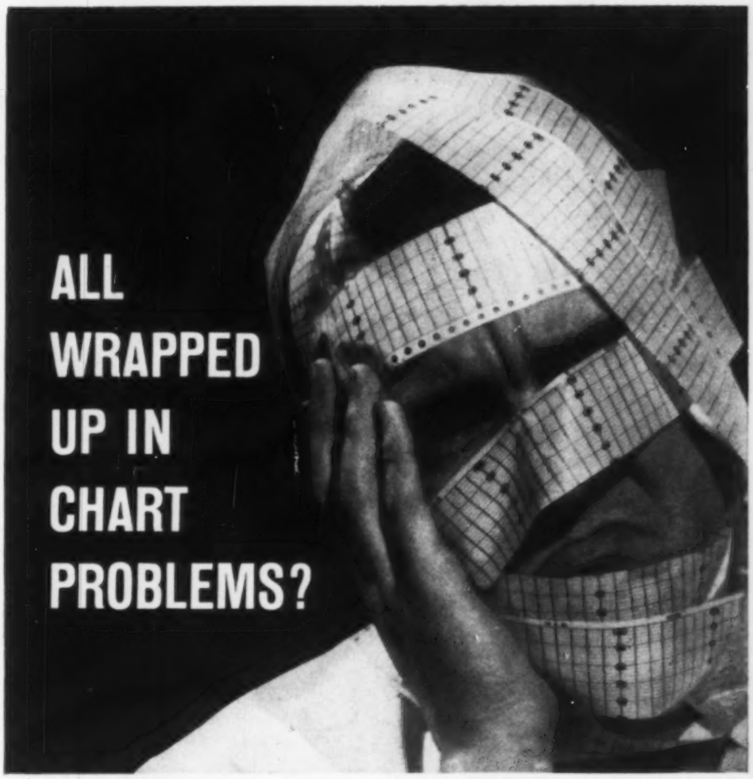
CIRCLE 211 ON READER-SERVICE CARD

IMPERVIOUS GRAPHITE DIAPHRAGM VALVES



New series of small-diameter impervious-graphite-body Diaphragm Valves with a Hills-McCanna (Saunders patent) bonnet features high C_v factor. Diaphragm material is normally Teflon. Valves are unaffected by almost all corrosives, are immune to effects of thermal shock, are non-contaminating, accommodate operating pressures to 50 psi at temperatures to 340° F and can handle gas, liquids, or slurries.—*Fall Industries, Inc., Aurora Rd., Solon, Ohio.*

CIRCLE 212 ON READER-SERVICE CARD



NO NEED TO BE . . . Bristol has met all the problems before . . . and has the answers!

If you need a special chart for that instrument you're designing, The Bristol Company's experienced staff of chart engineers stands ready to provide it for you . . . especially and expertly designed for your instrument . . . printed in one of the largest and best chart printing facilities in the country.

With almost 70 years of experience in the recording instrument business, Bristol really understands chart problems. What's more, Bristol's extensive facilities allow *fast* production of *all* types of charts—up to 32" wide in strip charts, 12" diameter for round charts. It doesn't matter how you intend to record—ink, hot stylus, electro-sensitive, light beam, or what have you—Bristol produces charts for all of them.

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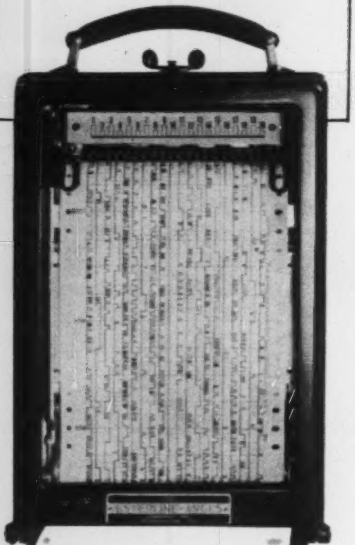
EVENT RECORDERS are doing to improve operations and cut costs!



Check Switch Assemblies.

Monitor Plastic or Metal Molding Operations.

Plot Movement of Conveyors.

Show Idle Time of Automatic Machines.

Monitor Electrical Substation Operation.

See how E-A Event Recorders can help you with accurately recorded, unbiased information.

Send for Catalog Section 50.

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No. 1 in fine Graphic Instruments for more than 50 years.

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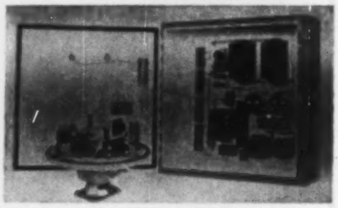
CIRCLE 313 ON READER-SERVICE CARD

SOLENOID VALVES

New 1500-Series Solenoid Valves feature direct lift action and full-ported construction to insure operation regardless of pressure drop or flow conditions. Bubble-tight, leakproof and packless, they are available in bronze or stainless steel in ¼" to 1" pipe sizes.—*Atkomatic Valve Co., 545 W. Abbot St., Indianapolis, Ind.*

CIRCLE 213 ON READER-SERVICE CARD

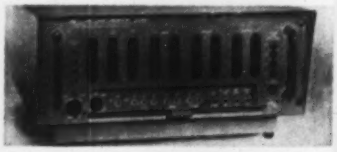
MAGNETIC DISC MEMORY



New all-transistor version of the Magdelay memory technique provides fast-response on-off signal storage and retrieval synchronized with product flow in automated process lines. Line speeds from 100 ft/min to a dead stop are accommodated by using static flux detector heads with 1200-cycle reset frequency. Response times match product transport lag within two msec or 0.2% of transport distance.—*Automation Inc., 212 Worcester St., Wellesley Hills 82, Mass.*

CIRCLE 214 ON READER-SERVICE CARD

TIME CODE GENERATOR



New Model ZA-810 Time Code Generator, an all-solid-state unit, has the same code (36-bit, 100 pps) as that now proposed for a world-wide timing system. Suitable for laboratory or field use as the heart of an instrumentation timing accuracy and stability (three parts in 10^9) are equivalent to a secondary standard.—*Electronic Engineering Co. of Calif., 1601 E. Chestnut Ave., Santa Ana, Calif.*

CIRCLE 215 ON READER-SERVICE CARD

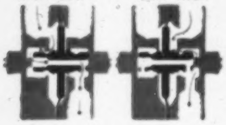
AUTOMATIC HIGH OR LOW *Pneumatic* **PRESSURE SELECTION**

with New "Mite" 71

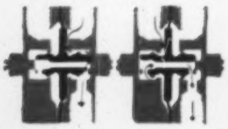
The "MITE" 71 can be easily field-changed, without special tools, from High-to-Low or Low-to-High signal selection. Hysteresis-free diaphragm assures rapid switch-over at minimum pressure differential.

- Rugged, simple construction
- One free-floating part
- Overall Dimensions — 2⅜" dia. X 2⅜" long
- Connections — ¼" NPT

SELECTING HIGH SIGNAL



SELECTING LOW SIGNAL



For detailed information on the "MITE" Series, contact

GEORGE W. DAHL COMPANY, INC.

86 TUPELO STREET
BRISTOL, RHODE ISLAND
CLifford 3-9500

VALVES AND CONTROLS FOR THE COMMUNICATIONS, PROCESS, AIRCRAFT AND MARINE INDUSTRIES

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Twin Seal Pressure Test Unit

Buy one unit . . .

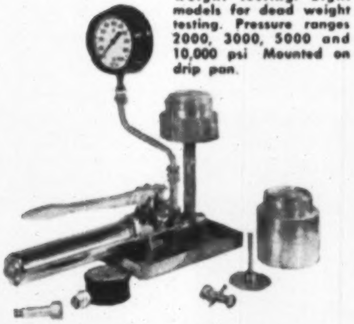
. . . do THREE jobs!

1. **Portable Testing**
2. **Bench Comparator Testing**
3. **Bench Dead Weight Testing**

Pump suitable for any pressure to 10,000 psi. Complete fittings to service all pressure instruments.

TWIN SEAL Pressure Test Unit arranged for portable testing. Weight filled with oil approximately 11½ lbs.

TWIN SEAL Pressure Test Unit arranged for bench work with test gage. Precision pressure adjustment. Mounted on short drip pan.



TWIN SEAL Pressure Test Unit arranged for dead weight testing. Eight models for dead weight testing. Pressure ranges 2000, 3000, 5000 and 10,000 psi Mounted on drip pan.

***NEW* fully illustrated catalog on TWIN SEAL Pressure Test Unit.**

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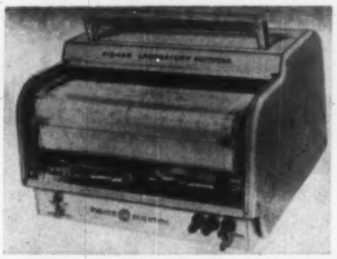
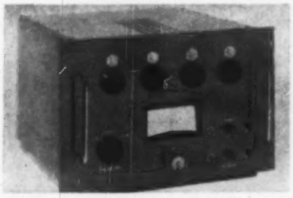
LABORATORY RECORDER



New Laboratory Recorder records temperature and monitors photocell output or any instrument reading that can be converted into d-c millivolts. Features include: fast response (less than 0.6 sec for the 9.5"-wide chart paper), "gear-shift" control whereby a little lever like the one on the steering column of an automobile gives instant choice of 5 chart speeds (0.5, 1, 2, 4, or 8"/min), and high stability.—*Fisher Scientific Co., 360 Fisher Bldg., Pittsburgh 19, Pa.*

CIRCLE 216 ON READER-SERVICE CARD

HI-VOLTAGE POWER SUPPLY



New high-voltage D-C Power Supply, Model 410A HV, is rated at 1-10.01 kv and 0-10 ma, featuring 0.01% regulation, stability of 0.005%/hr and output ripple less than 5 mv. Voltage output is indicated to an accuracy of 0.25%, with a resolution of 10 mv over the entire output range.—*John Fluke Mfg. Co., Inc., Box 7161, Seattle 33, Wash.*

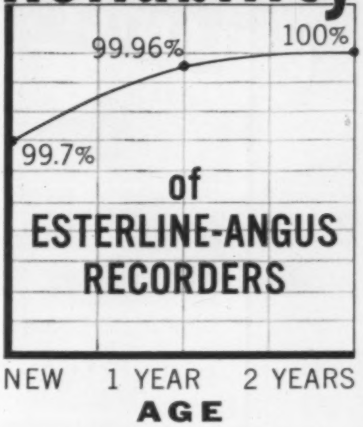
CIRCLE 217 ON READER-SERVICE CARD

SINE WAVE TRANSFORMER

New Sine Wave (7%-distortion) Constant Voltage Transformer in 60- and 400-cps units with a line variation of 95v to 130v, has constant output within ± 1½% and a current-limiting feature which prevents excessive fault currents.—*Freed Transformer Co., Inc., 1718 Weirfield St., Brooklyn (Ridgewood) 27, N. Y.*

CIRCLE 218 ON READER-SERVICE CARD

Reliability



of ESTERLINE-ANGUS RECORDERS

● **All E-A Recording Instruments are now guaranteed for two years.** The above reliability curve covering the past several years, shows why. The reliability which starts quite high in a new instrument, increases to practically 100% at the end of two years—and stays there. E-A instruments are designed and built to give ten years of trouble-free service.

Reliability like this is not quickly nor easily achieved. It takes years of development, testing and improvement . . . production know-how resulting from long experience . . . plus conscientious quality control, to attain this enviable record for reliability. Our one goal for over five decades has been to produce this one product—the reliable Esterline-Angus recording instrument.

In today's space-age technology, reliability of a high order is more important than ever before. Reliability Engineers stress that simplicity increases reliability. Simplicity also pays dividends in ease of operation and the ability to keep operating. Since the E-A recorder has simplicity and reliability, it is a proven choice for today's requirements.

Yes, proven by years of use in thousands of successful applications. We invite you to learn more about these applications. Representatives in all principal cities and in many foreign countries.

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CIRCLE 116 ON READER-SERVICE CARD

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**PYRO
OPTICAL
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- **Direct reading**
- **Rugged**
- **Standard ranges 1400° F to 7200° F**

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BERGENFIELD 4, NEW JERSEY

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Proven, Dependable, Rear-Projection Type

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A Model and Size for Your Every Requirement

Series 80ooo
Series 10ooo
Series 120ooo

OUTSTANDING FEATURES

- All digits displayed on front viewing screen
- All digits uniform in size and intensity
- High-contrast viewing screen
- Digit style of your choice
- Colored digits of your choice
- Individual units may be group assembled for panel mounting

WRITE TODAY FOR COMPLETE SPECIFICATIONS
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PRICES

Series 10ooo
1⁹⁄₁₆" wide
2⅜" high
5⅜" long
$18.00 each

Series 80ooo
3¼" wide
5¼" high
11¹⁵⁄₁₆" long
$33.00 each

Series 120ooo
1" wide
1⁵⁄₁₆" high
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Quantity Prices On Request

INDUSTRIAL ELECTRONIC ENGINEERS, Inc.
5528 Vineland Avenue,
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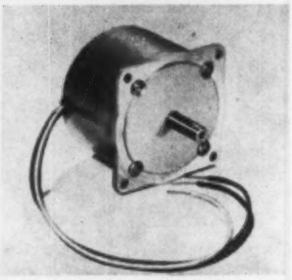
CIRCLE 118 ON READER-SERVICE CARD

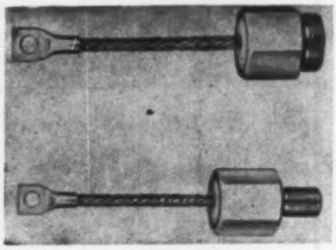
SYNCHRONOUS MOTOR



New Slo-Syn Synchronous Motor Type SS50, a permanent-magnet-type a-c motor, is ideally suited for a wide range of applications requiring constant, 72-rpm synchronous speed and/or d-c stepping with instant starting, stopping, or reversing. Ratings include: input 120 v, 40/70 cps, 1 phase, 0.30 amp max current (at 60 cps); 72 rpm output speed at 60 cps, 50 in-oz torque; weight 3 lb.—*Superior Electric Co., Bristol, Conn.*

CIRCLE 219 ON READER-SERVICE CARD

POWER RECTIFIERS



New Silicon Power Rectifier series composed of Styles ES-40 and ET-40 has peak forward voltages of 1.2 v max at 100 amp. The peak inverse current is 25 mamp at 100°C case temperature. Mounting torque for the ES-40 is 600 in-lb max and for the ET-40 it is 900 in-lb max.—*Syntron Co., Rectifier Div., 702 Lexington Ave., Homer City, Penna.*

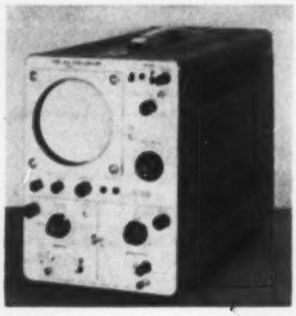
CIRCLE 220 ON READER-SERVICE CARD

MINI COAXIAL THERMOCOUPLE

New Miniature Thermocouples, available in total diameters as small as 0.0062", are very light in weight, offer the same reliability as standard-size thermocouples with extremely low thermal inertia, and permit probing into exact and normally inaccessible locations. These coaxial thermocouples feature a heat resistant insulating material that will not melt or exhibit dielectric breakdown under 3000°F. Currently available from stock are Copper-Constantan couples with a total diameter of 0.014". Other combinations that can be supplied are Chromel-Alumel, Fe-Constantan, and Platinum-Platinum /Rodium.—*Uniform Tubes, Inc., Collegeville, Penna.*

CIRCLE 221 ON READER-SERVICE CARD

OSCILLOSCOPE



New Type 504 Oscilloscope for the dc-to-450 kc range uses a minimum number of tubes (equivalent 17 plus rectifiers) for a maximum degree of reliability. Basic sensitivity is 5mv/cm. Vertical amplifier characteristics include: input stage electronically regulated, calibrated steps to 20 v/cm, adjustable between 12 steps and to over 50 v/cm uncalibrated, and constant input impedance (for easy probe use) at all sensitivities. —*Tektronix, Inc., Box 831, Portland 7, Ore.*

CIRCLE 222 ON READER-SERVICE CARD

INSTRULAB'S
NEW
evenvolt
Constant Voltage Unit

REPLACES BATTERIES
IN
POTENTIOMETERS
- CONTROLLERS
- INDICATORS
- RECORDERS

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INSTRULAB, INC.
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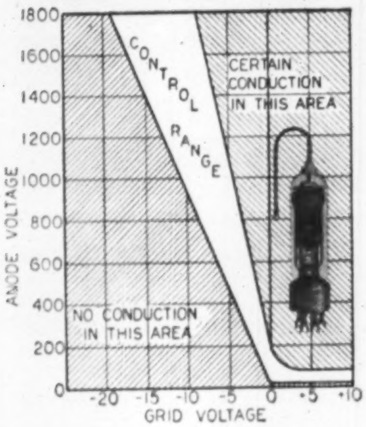
Outstanding FEATURES

- **Elimirates** batteries ...errors due to battery exhaustion
- **Reliable** construction...from quality components, long, trouble-free service
- **A Precise** voltage regulator . . . max. ±.04% for ±20% voltage variation
- **Quickly Installed...** Fits present instrument battery space.
- **No Tubes** to replace

CIRCLE 119 ON READER-SERVICE CARD

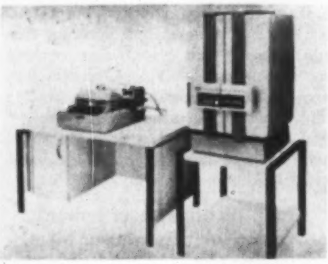
PURE XENON THYRATRONS



New line of Xenon Thyratrons, designated Models EL C6H-1 through EL C6H-5, capable of handling up to 1700 peak forward and inverse voltages, are rated at 130 commutation factor, low critical grid current, and an extremely narrow precisely-held control range. Features include low tube drop (11v avg.) with the greatest stability of control through wide ambient temperatures.—*Electrons, Incorporated,* 127 *Sussex Ave., Newark* 3, *N. J.*

CIRCLE 223 ON READER-SERVICE CARD

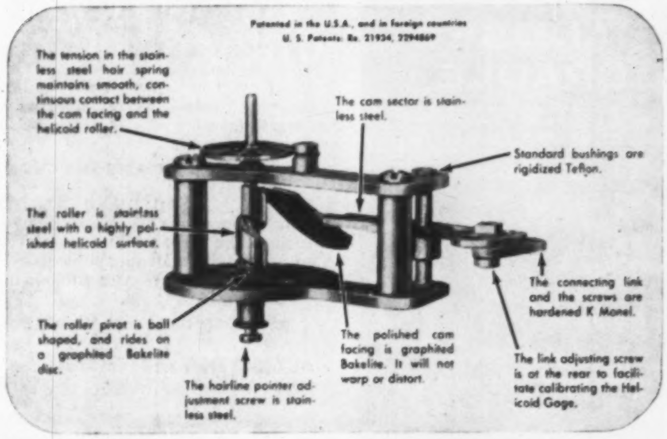
DIGITAL COMPUTER



New ultra-fast General-Purpose Digital Computer, combines a large, expandable memory and a versatile command structure with computing speed in the microsecond range. Priced at $30,000, the component line includes analog-to-digital converters, amplifiers, and digital modules. It is a serial, binary, single-address computer with an internally stored program. Features include: Expandable memory—1808 words, expandable to 15,888 words internally. Versatile command structure: 46 commands including double precision operations, block transfer, Gray-to-binary conversion. Simple programming: achieved by single address instructions, command indexing, and automatic double-precision operations, etc.—*Packard-Bell Computer Corp.,* 1905 *Armacost Ave., Los Angeles* 25, *Calif.*

CIRCLE 224 ON READER-SERVICE CARD

ACCO Helicoid Gage U.S.A.



Patented in the U.S.A., and in foreign countries
U. S. Patents: Re. 21934, 2294869
The tension in the stainless steel hair spring maintains smooth, continuous contact between the cam facing and the helicoid roller.
The cam sector is stainless steel.
Standard bushings are rigidized Teflon.
The roller is stainless steel with a highly polished helicoid surface.
The connecting link and the screws are hardened K Monel.
The roller pivot is ball shaped, and rides on a graphited Bakelite disc.
The polished cam facing is graphited Bakelite. It will not warp or distort.
The link adjusting screw is at the rear to facilitate calibrating the Helicoid Gage.
The hairline pointer adjustment screw is stainless steel.

Exclusive Helicoid movement provides...
Sustained Accuracy... on the toughest jobs

- Helicoid Gages have no gears, no teeth, reducing wear to an absolute minimum. No danger of fouling, either—rolling action of cam facing keeps contact surface clean. Helicoid Gages have been tested through 75,000,000 cycles, with virtually no wear or loss of accuracy, while conventional geared gages became useless after 500,000 cycles.

Helicoid Gages give *sustained* accuracy even when subjected to violent pressure pulsations or mechanical vibrations. Pointer can be set externally, without removing glass, and cannot be jarred out of position. Dial faces are easy to read, won't corrode or chip. A full range of Helicoid Gages is available for any application. Next time, specify Helicoid—the gage that *stays* accurate.

Bourdon Tubes won't Stretch, Leak, or Crack

Helicoid Bourdon tubes are made from seamless tubing, and are designed for maximum torque and minimum stress. At the factory, each tube is individually tested, overpressured, and stress relieved. Four materials—alloy steel, K Monel, stainless steel, and phosphor bronze—are available to meet applications ranging from tap water to almost any acid.

NEW! Solid-Front Safety Case Gives Added Protection

The new Helicoid solid-front case diverts the force of a burst in a backward direction, away from the operator. The force escapes by deforming, though not detaching, the back cover plate. Helicoid Gages are also available in phenol, acaloy flanged, acaloy flangeless, polished flangeless, round flush, polished flush ring, and square flush cases.

WRITE for details

Ask for Catalog DH-65

HELICOID GAGES

Helicoid Gage Division • American Chain & Cable Company, Inc.
929-B Connecticut Ave., Bridgeport 2, Conn.

ACCO

CIRCLE 120 ON READER-SERVICE CARD

NEW
STROMBERG-CARLSON
TELEPHONE
HANDSET
CRADLE

... for positive retention in all mobile applications

There's no jump, no sway—when a telephone handset is in the firm grip of this new handset cradle by Stromberg-Carlson.

Retaining clip spring assembly assures positive retention in any mobile application on land or sea, or in the air. Even extremely severe jars, jolts and vibrations fail to dislodge the handset.

The cradle is strong and resilient, fits any Stromberg-Carlson handset. Different models provide varying switch combinations with 2 or 4 Form C contacts. All models available with or without the clip assembly.

Specifications on request. In Atlanta call TRinity 5-7467; Chicago: STate 2-4235; Kansas City: HArrison 1-6618; Rochester: HUbbard 2-2200; San Francisco: OXford 7-3630. Or write to Telecommunication Industrial Sales, 113 Carlson Road, Rochester 3, New York.

STROMBERG-CARLSON
A DIVISION OF
GENERAL DYNAMICS

CIRCLE 121 ON READER-SERVICE CARD

ICS NEW LITERATURE

CONTOL SYSTEMS

PROCESS CONTROL SYSTEMS. 12-page booklet outlines graphically the Daystrom approach to industrial process control systems.—Daystrom, Inc., Control Systems Div., La Jolla, Calif.

CIRCLE 225 ON READER-SERVICE CARD

NUCLEAR REACTOR CONTROLLER. 4-page Specification Sheet S801-3 describes the three-mode nuclear reactor controller.—Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Phila. 44, Pa.

CIRCLE 226 ON READER-SERVICE CARD

AUTOMATION SYSTEMS. 16-page Bulletin GED-3908 titled "Automation and You," a management-oriented publication, discusses technology, equipment, and economics of automation.—General Electric Co., Schenectady 5, N. Y.

CIRCLE 227 ON READER-SERVICE CARD

TELEMETERING SYSTEMS. 52-page Bulletin M1715 describes with examples application of the impulse-duration principle of Metameter telemeters.—Bristol Co., Waterbury 20, Conn.

CIRCLE 228 ON READER-SERVICE CARD

PROCESS INSTRUMENTS. 12-page Catalog 515 describes pneumatic instruments for the process industries. —U. S. Gauge Div. American Machine and Metals, Inc., Sellersville, Penna.

CIRCLE 229 ON READER-SERVICE CARD

PROCESS COMPUTER CONTROL. 28-page Bulletin S-4019, "A Return to Sanity in Computer Control," cuts through the confusion surrounding the subject of process computer control. —Beckman Scientific and Process Instruments Div., Fullerton, Calif.

CIRCLE 230 ON READER-SERVICE CARD

VALVES

CONTROL VALVES. 2-page Data Sheet No. 101 describes and shows features of construction and complete specs on the Series LB control valves.—Conoflow Corp., 2100 Arch St., Phila. 3, Pa.

CIRCLE 231 ON READER-SERVICE CARD

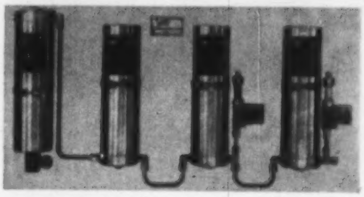
PRESSURE REGULATORS. 8-page Catalog J160-1 gives up-to-date information on the complete line of sliding-gate pressure regulator.—OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

CIRCLE 232 ON READER-SERVICE CARD

WATER DRAW-OFF VALVE. 2-page Bulletin No. 500-2-1 features high flow-capacity and packless valves of non-freezing construction.—Johnston & Jennings Co., 4700 West Division St., Chicago 51, Ill.

CIRCLE 233 ON READER-SERVICE CARD

When water or oil
in gases cannot
be tolerated . . .



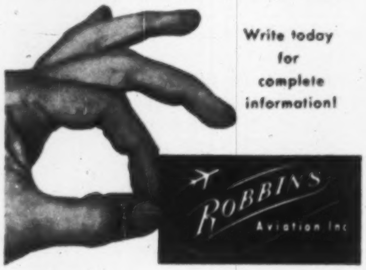
INSTALL ROBBINS
dehydration
equipment

Robbins Aviation offers you both disposable cartridge type and refrigeration type dehydration systems for practically all types of gases... equipment designed and built to rigid quality control standards to give you maximum satisfaction in efficient trouble-free performance.

Robbins equipment is used extensively for aircraft pneumatic systems, test laboratory equipment, mobile compressor trailers, hydraulic system purging, missile charging and pressurizing systems, for instrument, laboratory, and factory air, controlled atmospheres for brazing and heat-treating furnaces, etc. Mechanical filters, drier and purifier chambers, refillable and disposable cartridges, dewpoint indicators also available.

Fast, positive, economical
removal of water or oil
vapor and impurities

Pressures to . . . . . . 12,000 PSI
Safety Factor . . . . 4 to 1
Dewpoints to . . . . . . −100°F
Oil Vapor
Removed to . . . as low as 0.3 ppm/w



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LUdlow 9-5221

CIRCLE 122 ON READER-SERVICE CARD

WATER CHECK VALVES. 4-page Bulletin WS-1A describes double-cushioned check valves.—Golden Anderson Valve Specialty Co., 1285 Ridge Ave., Pittsburgh 33, Pa.

CIRCLE 234 ON READER-SERVICE CARD

TEMPERATURE

SEALED TEMPERATURE DETECTOR. 2-page Product Specification E51-5 contains complete technical details on sealed resistance-type temperature detector.—Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

CIRCLE 235 ON READER-SERVICE CARD

T/C'S AND EXTENSION WIRE. 4-page Catalog No. 602 describes and specifies metallic-sheathed, hard-packed, oxide-insulated thermocouples and extension wire.—Marlin Mfg. Corp., 12404 Triskett Rd., Cleveland 11, Ohio.

CIRCLE 236 ON READER-SERVICE CARD

PUMPS, LEVEL

CONTROLLED CAPACITY PUMPS. 12-page Catalog 200 describes design features of the 200-Series pumps with charts for capacity-pressure and materials selection.—American Meter Co., Pump Div., 13500 Philmont Ave., Phila. 16, Pa.

CIRCLE 237 ON READER-SERVICE CARD

LIQUID LEVEL GAGES & VALVES. 8-page Catalog 376 covers maker's complete line of liquid level gages and valves with a condensed presentation of the most pertinent data and specifications.—Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass.

CIRCLE 238 ON READER-SERVICE CARD

PRESSURE, ACCELERATION

ELECTROMANOMETER. 4-page Bulletin 1547 describes the Electromanometer system.—Consolidated Electrodynamics Corp., a subs. of Bell & Howell Co., Transducer Div., 360 Sierra Madre Villa, Pasadena, Calif.

CIRCLE 239 ON READER-SERVICE CARD

INDICATING LIQUIDS. 2-page Manometer Catalog 2008 describes line of seven color-coded indicating liquids for manometers and hydrostatic gages.—King Engineering Corp., Box 730, Ann Arbor, Mich.

CIRCLE 240 ON READER-SERVICE CARD

ACCELEROMETER. 2-page Short Form Sheet T-101 shows a representative view of the maker's accelerometer line.—Columbia Research Labs., Inc., MacDade Blvd. and Bullens Lane, Woodlyn, Penna.

CIRCLE 241 ON READER-SERVICE CARD

TIME

PROGRAMMERS, CONTROLLERS. 72-page bound Condensed Catalog 63 contains bulletins, price lists, and illustrations of temperature and power controls, programmers, accelerometers, transducers, and heating ovens.—Research, Inc., Box 6164, Edina Station, Minneapolis 24, Minn.

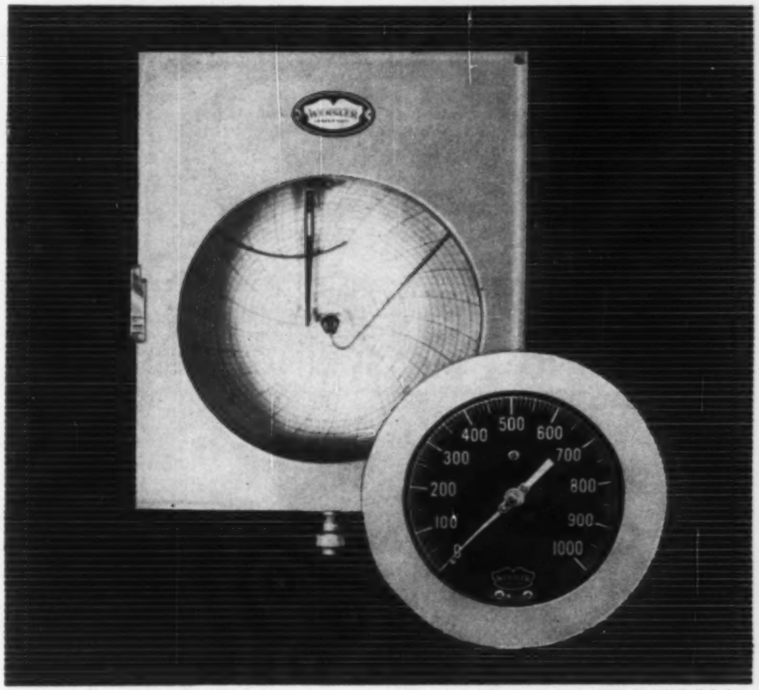
CIRCLE 242 ON READER-SERVICE CARD

WEKSLER INSTRUMENTS

SYMBOL OF QUALITY

in

Indicating and Recording Vacuum and Pressure Gauges



Pressure Recorders in 8", 10", 12" chart sizes

Pressure Gauges in 3½", 4½", 6", 8½" dial sizes

In the field of indicating and recording instruments for temperature, pressure and humidity, the name Weksler is internationally known for engineering and product excellence.

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Write for the helpful Weksler Specification Bulletin covering a complete line of Weksler instruments for specific applications.

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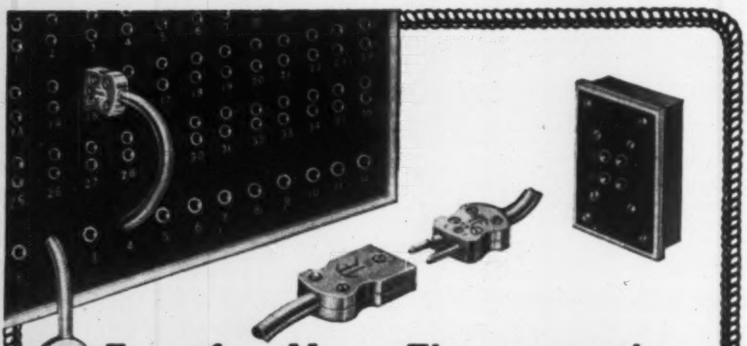
"ORIGINATORS OF WORLD RENOWNED ADJUST-ANGLE THERMOMETERS"

WEKSLER INSTRUMENTS CORP.
195 EAST MERRICK ROAD, FREEPORT, L. I., N. Y.
Indicating and Recording Instruments for Temperature, Pressure and Humidity

CIRCLE 123 ON READER-SERVICE CARD



Transfer Many Thermocouples

With T-E Quick-Coupling Connectors and Panels

Connector Panels T-E has one for your exact needs. These panels provide flexible, centralized control in transferring any number of thermocouples to indicating, multipoint recording and controlling pyrometers. Ideal for patch panel use, they are available in many compact shapes and sizes — with interchangeable plugs and jacks in I-C, C-C, and C-A. A panel for 48 thermocouples and 16 pyrometers measures only 13¼" x 7⅞". Polarity markings and screw-fastened connections make wiring easy.

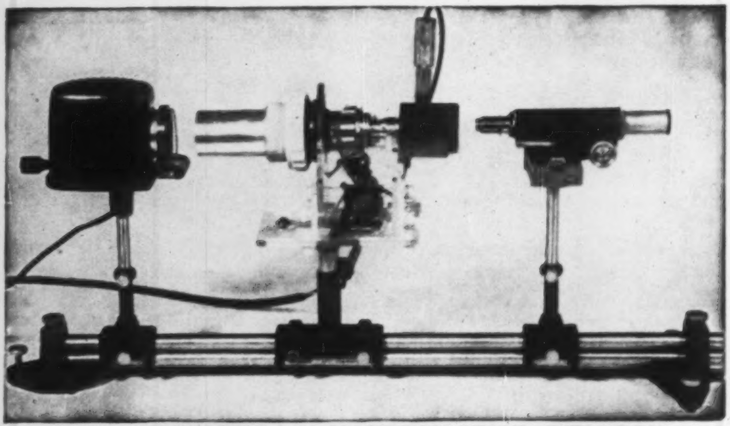
Quick-Coupling Connectors These connectors permit fast, easy making and breaking of thermocouple circuits. Durable construction guarantees long, dependable usage. Polarized and mechanically interchangeable, all plugs and jacks are of standard matched thermocouple materials. Spring-loaded contacts with long wiping surfaces provide firm but easily broken connections.

Write for Bulletin 23-12

Thermo Electric Co. Inc.
SADDLE BROOK, NEW JERSEY
In Canada — THERMO ELECTRIC (Canada) Ltd., Brampton, Ont.

CIRCLE 124 ON READER-SERVICE CARD

for TESTING • MEASURING • RESEARCH



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CIRCLE 125 ON READER-SERVICE CARD

SEQUENCE PROGRAMMER. Bulletin 360 describes Minimatic sequence programmer MSP-1 for precise timing and cycling of automated machinery. —Clippard Instrument Lab., 7390 Colerain Rd., Cincinnati 39, Ohio.

CIRCLE 243 ON READER-SERVICE CARD

AIR

COMPRESSED AIR PRODUCTS. 24-page Catalog 158a describes with illustrations and specs filters, regulators, lubricators, drains, etc.—Wilkerson Corp., Englewood, Colo.

CIRCLE 244 ON READER-SERVICE CARD

DRYERS. 6-page Bulletin HA-308 lists technical specifications and capacities of Heat-Les dynamic desiccant dryers.—Trinity Equipment Corp., Cortland, N. Y.

CIRCLE 245 ON READER-SERVICE CARD

AIR DRYERS. 4-page Bulletin DG2-1159-5 specifies 12 models and describes operation of two-stage unit acting as mechanical separator and chemical absorption dryer.—General Welding & Fabricating Co., 1702 Peninsula Dr., Erie, Pa.

CIRCLE 246 ON READER-SERVICE CARD

AIR COMPRESSORS. 12-page Bulletin GO-259 describes and illustrates with specs oil-less compressors eliminating costly lubrication and air contamination.—Bell & Gosset Co., Morton Grove, Ill.

CIRCLE 247 ON READER-SERVICE CARD

AIR FILTER. 4-page Bulletin 601 ES illustrates and describes panel-type filters.—Arco Mfg. Corp., 542 W. 55th St., New York 19, N. Y.

CIRCLE 248 ON READER-SERVICE CARD

LABORATORY

LABORATORY CONTROL. 24-page booklet "Quality Control and Research" tells how to go about producing a lower-cost but better-quality product.—SAMA, 20 North Wacker Drive, Chicago 6, Ill.

CIRCLE 249 ON READER-SERVICE CARD

CENTRIFUGE. 8-page bulletin describes the Servall RC-2 Automatic Superspeed Refrigerated Centrifuge. —Ivan Sorvall, Inc., Norwalk, Conn.

CIRCLE 250 ON READER-SERVICE CARD

DATA HANDLING

DIGITAL DATA PLOTTING. 8-page Bulletin #DP6001 describes Dataplotter, a digital data plotting instrument. —Electronic Associates, Inc., Long Branch, N. J.

CIRCLE 251 ON READER-SERVICE CARD

SCANNER SYSTEM. 4-page brochure contains discussion of GOAT (Gerber Oscillogram Amplitude Tabulator) system for reducing data recorded on film.—Gerber Scientific Instrument Co., 89 Spruce St., Hartford, Conn.

CIRCLE 252 ON READER-SERVICE CARD

CODEWRITER. 4-page Brochure IP-O1 describes the Codewriter, a new electronic component for data processing.—Royal McBee Corp., Industrial Products Div., 740 North Main St., West Hartford 17, Conn.

CIRCLE 253 ON READER-SERVICE CARD

COMPUTER APPLICATION. 4-page Application Note AN-101 describes use of Model 60B logarithmic converter as a computing element.—F. L. Moseley Co., 409 North Fair Oaks Ave., Pasadena, Calif.

CIRCLE 254 ON READER-SERVICE CARD

DIGITAL TRANSDUCERS. 2-page Bulletin 150 illustrates and describes the DX-100 Series of digital transducers. —Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.

CIRCLE 255 ON READER-SERVICE CARD

COMPUTER ABSTRACTS ON CARDS. 4-page leaflet describes a new technical abstracting service in the field of electronic computers.—Cambridge Communications Corp., 238 Main St., Cambridge 42, Mass.

CIRCLE 256 ON READER-SERVICE CARD

DATA PROCESSING. 2-page Application Report No. 11 describes an application of a computer system as related to accounting procedures.—Bendix Computer Div., 5630 Arbor Vitae St., Los Angeles 45, Calif.

CIRCLE 257 ON READER-SERVICE CARD

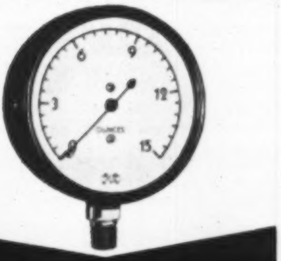
RECORDERS

OSCILLOGRAPH APPLICATIONS. 36-page manual illustrates the versatility of the direct-recording Visicorder oscillograph.—Heiland Div., Minneapolis-Honeywell, 5200 East Evans Ave., Denver, Colo.

CIRCLE 258 ON READER-SERVICE CARD

STRIP CHART RECORDERS. 14-page bulletin details full specs and data of maker's rectilinear multi-channel recorders, made in four case sizes.—Curtiss-Wright Corp., Carlstadt, N. J.

CIRCLE 259 ON READER-SERVICE CARD



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DIAPHRAGM GAUGES

for accurate pressure measurement in ounces or inches of water

Standard dials reading in inches of water, ounces, centimeters or millimeters up to 10 P.S.I. All Marshalltown diaphragm gauges are extremely sensitive and accurately measures very low pressures.

Let Marshalltown answer your gauge problems . . . write for information and prices.

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CIRCLE 126 ON READER-SERVICE CARD

Max Schweizer is a Specialist
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APTI-METER
TSI

...at "RACKING UP" RELIABILITY

That incredibly short (3½") rack-mounting counter-timer tucked under Max Schweizer's forearm is a tribute to the many years of **specialized** experience he brings to the position of Chief Mechanical Engineer at TSI. Every one of the 2162 components in the Model 361-R APTI®-METER* is logically located, thermally protected and instantly accessible. No "sardine packing" here!

Incidentally, Max found his job about 800 components easier, because our circuits group has achieved what we call **"reliability through sophisticated simplicity"** in the 360 Series. His superb packaging job further enhanced that reliability — and the Model 361-R bears **a 5-year guarantee.**

If you like sharp contrasts, compare this cool, compact, all-solid-state beauty with the hot-as-a-pistol vacuum-tube monsters five times its height and weight, not nearly as versatile or convenient.

Why plod along with **old-fashioned** counters? Let us send you literature on the **newest** — Model 361-R APTI®-METER, the **only** 1 MC solid-state counter!

**APTI®-METER is our registered trade-mark for an ACTIONS-PER-TIME-INTERVAL meter. Model 361-R counts from 0-1MC, has crystal-plus-oven stability of 0.3 ppm/week, IN-LINE NIXIE READ-OUT, and identical-twin, high-impedance, high-sensitivity amplifiers. Features galore, unlimited flexibility, yet the sensible-compromise price is only $1680.*

TSI **TRANSISTOR SPECIALTIES INCORPORATED**
Sophisticated Digital Instrumentation

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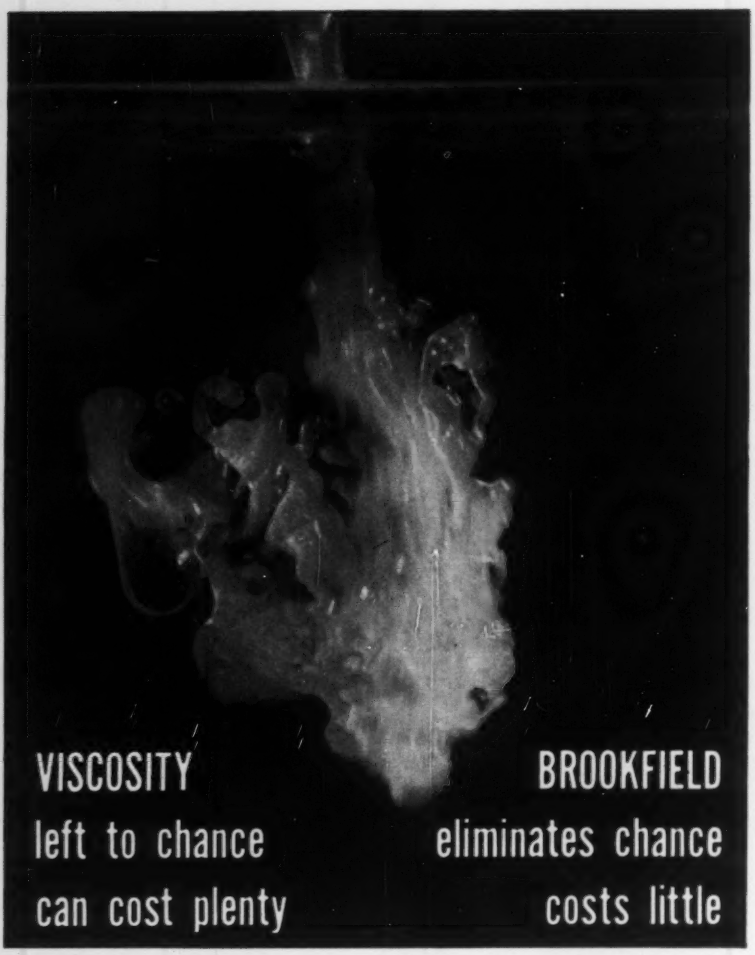
CIRCLE 127 ON READER-SERVICE CARD



If you, like most chemical processors, are in the rough marketing position whereby you can't tolerate needless production waste . . . then give this some thought.

Have you considered the role of viscosity control in your processes? If not — you should! Viscosity is a product dimension that experience has shown should not be ignored . . . a product dimension Brookfield has proved need not be ignored. Both Brookfield laboratory Synchro-Lectric Viscometers and process-mounted Viscometrans involve small investments: yet they provide easy, accurate measurement, evaluation and control of viscosity in any fluid. Brookfield instrumentation is so simple that no special personnel training is required for operation.

Complete information, specific to your particular problems, if you wish, is available without obligation. Write today.

THE WORLD'S STANDARD FOR VISCOSITY MEASUREMENT AND CONTROL

Brookfield

ENGINEERING LABORATORIES, INCORPORATED
STOUGHTON 116, MASSACHUSETTS

CIRCLE 128 ON READER-SERVICE CARD

MAGNETIC TAPE RECORDER. 2-page Bulletin 58 describes the 16-channel digital magnetic tape recorder, Model PS-216-D.—Precision Instrument Co., San Carlos, Calif.

CIRCLE 260 ON READER-SERVICE CARD

CHART DRIVES. 4-page Bulletin 255 and 2-page Bulletins 267, 271, 272, and GET-3024 describe multi-speed chart drives for use with Bristol, Wheelco, Leeds & Northrup, and General Electric strip chart recorders. —Insco Co., Div. of Barry Controls, Hollis St., Groton, Mass.

CIRCLE 261 ON READER-SERVICE CARD

IMPACT RECORDER. 4-page brochure details new shock-recording instruments.—IMPACT-O-GRAPH Corp., 1900 Euclid Ave., Cleveland 15, Ohio.

CIRCLE 262 ON READER-SERVICE CARD

MONITORS

ANNUNCIATOR SYSTEMS. 24-page catalog illustrates and describes industrial lamp annunciator systems.—Edwards Co., Inc., Norwalk, Conn.

CIRCLE 263 ON READER-SERVICE CARD

LEGEND LIGHT. 2-page catalog sheet describes a flush-mounting legend light for airborne or ground support applications.—Radar Relay, Inc., 2322 Michigan Ave., Santa Monica, Calif.

CIRCLE 264 ON READER-SERVICE CARD

SIGNAL MANUAL. 88-page Catalog 160 describes air and electric signal systems and lists specifications of horns, bells, buzzers, chimes, and sirens.—Sperti Faraday, Inc., Adrian, Mich.

CIRCLE 265 ON READER-SERVICE CARD

TESTING

TESTING INSTRUMENTS. 16-page Folder E(6) describes line of laboratory and testing instruments.—Leeds & Northrup, 4934 Stenton Ave., Phila. 44, Pa.

CIRCLE 266 ON READER-SERVICE CARD

SURGE TEST ADAPTER. 2-page Data Sheet 107 describes the self-contained 75-amp surge test adapter Model 142 A.—Wallson Assocs., 912-914 Westfield Ave., Elizabeth, N. J.

CIRCLE 267 ON READER-SERVICE CARD

CIRCUIT BREAKER TESTER. 16-page Bulletin SB-CB-1 describes how low-voltage power circuit breakers and molded-case circuit breakers can be tested with test units.—Multi-Amp Div., Multi-Amp Electronic Corp., Box 217, Union, N. J.

CIRCLE 268 ON READER-SERVICE CARD

TEST AND SENSING COMPONENTS. 8-page vest pocket guide and wall chart helps the design engineer choose the right test and sensing component. —Alden Products Co., Dept. TS, 117 N. Main St., Brockton 64, Mass.

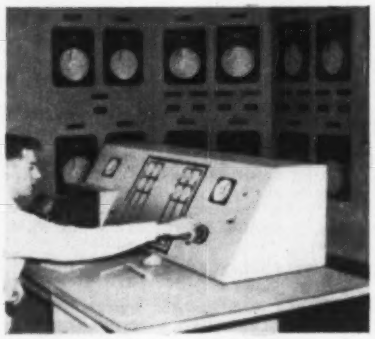
CIRCLE 269 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC INSTRUMENTS

DIGITAL VOLT-OHMMETER. 6-page folder with a full-size cover picture describes and specifies new Epsco DVOM.—Epsco Inc., 275 Massachusetts Ave., Cambridge 39, Mass.

CIRCLE 270 ON READER-SERVICE CARD

AUTOMATION
ECONOMY



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American® telemetering and telecounting equipment helps one man do the work of many ...in gathering fields, transmission and distribution systems.

One man at a central dispatching station instantly receives accurate flow and pressure readings from remote points and adjusts for demand with remote-set controllers.

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American Telecounters accurately transmit Base Volume Index indications of gas quantities computed to base temperature and base pressure conditions, to central locations.

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CIRCLE 129 ON READER-SERVICE CARD

DIGITAL VOLTMETER. 4-page Bulletin 64-1 describes and illustrates low-cost V64 digital voltmeter.—Non-Linear Systems, Inc., Del Mar, Calif.

CIRCLE 271 ON READER-SERVICE CARD

MICROWAVE EQUIPMENT. 32-page Catalog 60 provides information on microwave receiver front ends including data on a number of waveguide and coaxial mixer-preamplifier assemblies.—LEL Inc., 380 Oak St., Copiague, L. I., N. Y.

CIRCLE 272 ON READER-SERVICE CARD

ELECTRICAL METERS. 8-page bulletin illustrates and describes ammeters and voltmeters of many ranges; and aircraft instruments, frequency meters, time indicators, and accessories.—WacLine, 35 South St. Clair St., Dayton 2, Ohio.

CIRCLE 273 ON READER-SERVICE CARD

PRINTED-CIRCUIT MOTORS. 2-page Technical Data Sheets 3120 on the Model 368, and 3140 on the Model 488 describe the servo motor's thin, flat printed-circuit armature.—Printed Motors, Inc., 33 Sea Cliff Ave., Glen Cove, N. Y.

CIRCLE 274 ON READER-SERVICE CARD

SYNCHROS AND RESOLVERS. 27-page manual discusses the electrical characteristics of synchros and resolvers.—Theta Instrument Corp., 520 Victor St., Saddle Brook, N. J.

CIRCLE 275 ON READER-SERVICE CARD

POTENTIOMETER TRANSDUCERS. 4-page bulletin contains specification data of potentiometer transducers for pressure, motion, altitude, weight, flow, indicating, recording, systems, and controlling.—H. E. Sostman & Co., 445 East Lincoln Ave., Cranford, N. J.

CIRCLE 276 ON READER-SERVICE CARD

BRIDGES, COMPONENTS. 4-page Condensed Catalog A-26 provides descriptive information on impedance, resistance, capacitance bridges, and decade-type voltage dividers, resistors, and capacitors.—Electro Scientific Industries, 7524 S.W. Macadam Ave., Portland 19, Ore.

CIRCLE 277 ON READER-SERVICE CARD

ELECTRICAL INSTRUMENTS. 8-page Bulletin D-100 describes and explains uses of pulse-height analyzers, scalers, linear amplifiers, photomultiplier photometers, etc.—Eldorado Electronics, 2821 Tenth St., Berkeley 10, Calif.

CIRCLE 278 ON READER-SERVICE CARD

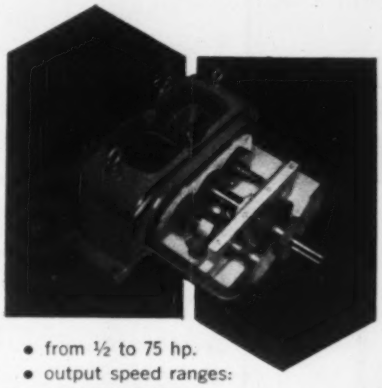
VOLTAGE REGULATOR. 2-page flyer describes and specifies the Model 4-28 miniature solid-state voltage regulator.—Acton Labs., Inc., Space Instrumentation Div., subs. of Technology Instrument Corp., 533 Main St., Acton, Mass.

CIRCLE 279 ON READER-SERVICE CARD

STEP DOWN TRANSFORMER. 2-page Bulletin 16-BO1 provides specs and data with application examples of common step down transformers.—Acme Electric Corp., Cuba, N. Y.

CIRCLE 280 ON READER-SERVICE CARD

Specify
SPECON for
VARIABLE
SPEED
DRIVES
electrical and mechanical



- from ½ to 75 hp.
- output speed ranges: 0-100 to 0-7000 rpm
- smoothly adjustable through zero speed
- draw accuracies of .01%
- full torque at zero speed

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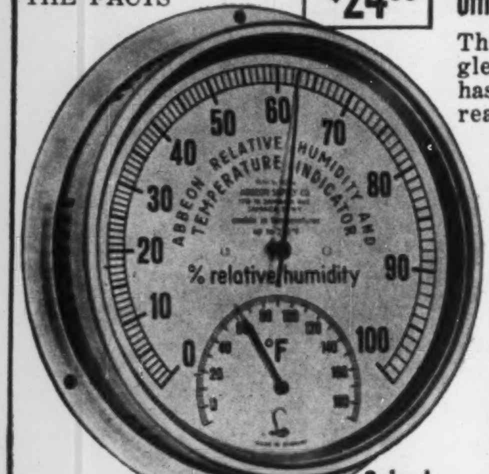

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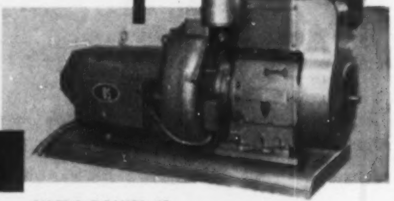

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TULSA DIVISION . . .
assures effectiveness of its protective boiler flame controls with . . .

MICRO POWER

In plants like Douglas Aircraft Company, Inc., in Tulsa, Oklahoma, where a continual supply of steam is vital to production processes, every precaution must be taken to assure against the hazards of boiler flame-out. To safely regulate its burners in the event of flame-out, the company utilizes highly sensitive electric controls. Since these flame failure controls *are* electric and must depend on a constant, unwavering power supply for successful operation, this is achieved with MICRO POWER.

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- for refinery and chemical process indication and control.
- by public utilities through microwave for protective relaying, telemetering and load distribution.

MICRO POWER PROVIDES . . .

- a constant uninterrupted source of electric power.
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- stable voltage output.
- flywheel starting — no storage batteries.
- electrical isolation from commercial source — voltage dips, peaks and breaks do not affect microwave equipment, no transfer switch.

For complete information on this and other Micro Power applications, write . . .

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CIRCLE 132 ON READER-SERVICE CARD

ICS NEW LITERATURE

MINI TRANSISTOR AMPLIFIER. 2-page Catalog Sheet A-402 illustrates and describes Mini-Amp transistorized amplifier and Mini-Mix audio mixer. —Switchcraft, 5555 N. Elston Ave., Chicago 30, Ill.

CIRCLE 281 ON READER-SERVICE CARD

POTS, RESISTORS

A-C POTS. 12-page comprehensive catalog describes design features, applications, and operation of "Vernistat" a-c potentiometers.—Vernistat Div., Perkin-Elmer Corp., Norwalk, Conn.

CIRCLE 282 ON READER-SERVICE CARD

HI-TEMP RESISTORS. 2-page Bulletin CE-2.07 describes high-temperature, non-inductive resistors.—Corning Electronic Components, a dept. of Corning Glass Works, Corning, N. Y.

CIRCLE 283 ON READER-SERVICE CARD

POWER SUPPLIES

TRANSISTORIZED POWER SUPPLIES. 4-page brochure contains information and specifications on d-c/d-c converters, d-c/a-c inverters, and a-c/d-c power supplies.—Electrodynamic Instrument Corp., 1841 Old Spanish Trail, Houston 25, Tex.

CIRCLE 284 ON READER-SERVICE CARD

D-C POWER SUPPLIES. 16-page catalog illustrates and specifies entire line of d-c power supplies.—Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

CIRCLE 285 ON READER-SERVICE CARD

ELECTRICAL, ELECTRONIC COMPONENTS

SURGE PROTECTORS. 4-page Bulletin EPD 3135-1 describes line of Captivolt (TM) surge protectors for silicon rectifiers.—Vickers, Inc., Electric Products Div., 1815 Locust St., St. Louis 3, Mo.

CIRCLE 286 ON READER-SERVICE CARD

HIGH-DENSITY DELAY LINES. 18-page booklet describes the advantages, disadvantages and limitations of all the different types of delay lines on the market.—Valor Instruments, Inc., 13214 Crenshaw Blvd., Gardena, Calif.

CIRCLE 287 ON READER-SERVICE CARD

HIGH-VOLTAGE PENTODE. 4-page Form 2156-9 describes with curves high voltage pentode tube.—Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.

CIRCLE 288 ON READER-SERVICE CARD

COMPRESSION TERMINALS. 6-page Bulletin TCT-59-102 illustrates 23 styles of glass-to-metal hermetically sealed terminals and tabulates dimensions and electrical specs.—Electrical Industries, 691 Central Ave., Murray Hill, N. J.

CIRCLE 289 ON READER-SERVICE CARD

MATERIALS

POWDERED PERMALLOY CORES. 12-page Bulletin G1 presents extensive information on powdered permalloy Filtoroid cores.—Magnetic Metals Co., Hayes Ave. at 21st St., Camden, N. J.

CIRCLE 290 ON READER-SERVICE CARD

POLYOLEFIN MOLDINGS, for nuclear and prototype application are described and tabulated in 4-page bulletin.—American Agile Corp., Box 168, Bedford, Ohio.

CIRCLE 291 ON READER-SERVICE CARD

MISCELLANEOUS

FLEXIBLE SHAFT ASSEMBLIES. 4-page Form 574 describes and tabulates flexible shaft assemblies.—F. W. Stewart Corp., 4311-13 Ravenswood Ave., Chicago 13, Ill.

CIRCLE 292 ON READER-SERVICE CARD

INFRARED SENSORS. 4-page brochure "Kodak Ektron Detectors—for the Infrared" illustrates and describes characteristics of these products which find application as infrared sensors.—Eastman Kodak Co., Rochester 4, N. Y.

CIRCLE 293 ON READER-SERVICE CARD

CAT WHISKER WELDER. 2-page leaflet illustrates and describes features of cat whisker welding and beading machine for glass diodes.—Kahle Engineering Co., 3322 Hudson Ave., Union City, N. J.

CIRCLE 294 ON READER-SERVICE CARD

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JAMAICA 35, N. Y.

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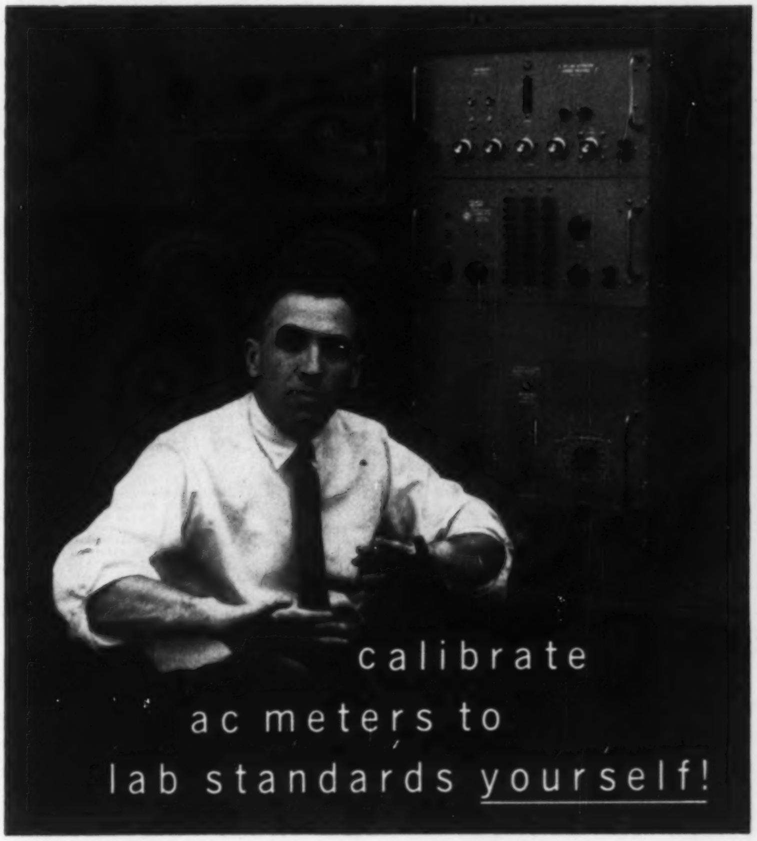

with this stable,

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New from Krohn-Hite: this variable-frequency, 50 watt ac power source, with less than 0.01% amplitude stability and 0.1% harmonic distortion! The LDS-1500 offers a continuously-variable wide range of voltage and current — up to 1500 volts, and up to 12 amps, at *any* frequency from 20 cps to 20 kc.

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As a general-purpose variable frequency source of distortion-free, highly stable power, the LDS-1500 has many other applications. Quality-control testing for distortion or performance of components requiring a variety of power supply frequencies is simplified. The 50 watt power output is ample to supply test benches.

Send for full information on this unusual ac power source!

KROHN-HITE CORPORATION
580 Massachusetts Avenue • Cambridge 39, Mass.
Pioneering in Quality Electronic Instruments

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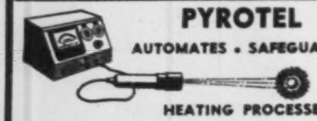
ICS SEARCHLITE SECTION



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PORTABLE and STATIONARY
To indicate
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Bulletin No. 1048

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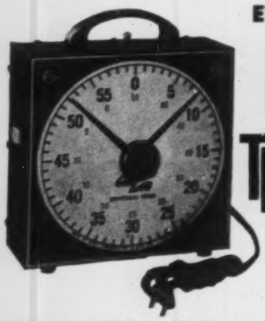

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Setting Range: —35°C to 370°C
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Guaranteed sensitivity . . . year-in, year-out reliability . . . accurate control of temperature in ovens, electronic equipment, baths, ducts, freezers, fire alarms, incubators, analytic instruments, etc. Triple distilled mercury; filled at still. Hermetically sealed with dry hydrogen at 75 psi. Calibrated to Bur. Standards accuracy. Priced 10% to 15% lower than competitive lines.

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integrate measured variables on your present recorder

ROYSON INTEGRATOR KIT

FEATURES:

- integrates continuously while variable is being recorded.
- eliminates error, extra cost as recorder's servo is used.
- provides up to 1000 counts per minute.
- extra contact every ten counts for dual pipping pen action.
- can be field installed on most recorders.
- pipping pens and other readout devices are available.

Write, wire or call for details.

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Hatboro, Pa. • OSborne 5-2800

CIRCLE 140 ON READER-SERVICE CARD

Model HT-12 Four-Range Tachometer

Centrifugal tachometer that measures revolutions per minute and surface speeds.

TOTAL RANGE: 90-12,000 RPM
1st — 90-360 RPM
2nd — 300-1200 RPM
3rd — 900-3600 RPM
4th — 3000-12000 RPM

Feet per minute—one half the dial reading with use of 6" disc wheel.
Price — $80.00

Advantages: Accuracy—±0.5% • Stop button feature • Instantaneous readings • 3" easy to read dial • Light—approx. 14 oz.

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EMPLOYMENT OPPORTUNITY

FIELD ENGINEER FOR IN-PLANT INSTRUMENT CALIBRATION

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ICS NEW LITERATURE

HOSE FITTING KITS. 2-page Catalog Sheet 4482A22 describes handy kits of industrial hose with Parker "Push-lok" fittings.—Parker-Hannifin Corp., Parker Fittings & Hose Div., 17325 Euclid Ave., Cleveland 12, Ohio.

CIRCLE 295 ON READER-SERVICE CARD

PUSH BUTTON SWITCH. 2-page Bulletin 5500 illustrates and describes momentary-action type switch.—Donald P. Mossman, Inc., Brewster, N. Y.

CIRCLE 296 ON READER-SERVICE CARD

FACILITIES. 16-page brochure describes the facilities for company's engineering, production and testing in prime and sub-contracting.—Melpar, Inc., a subs. of Westinghouse Air Brake Co., 3000 Arlington Blvd., Falls Church, Va.

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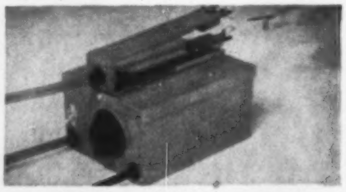

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Use either as bench or hand tool.
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ICS PEOPLE IN THE NEWS

LEEDS & NORTHRUP announces that *C. Reed Cary*, chairman of the board, has retired after 53 years of service, but will continue serving on the board.

MINE SAFETY APPLIANCES CO. has appointed *Nelson W. Hartz* director of marketing for all industrial operations, and *John P. Sherwin* sales manager of the technical products division.

N. W. HARTZ
M.S.A.

J. P. SHERWIN
M.S.A.

TECHNOLOGY ASSOCIATES announces that *Ronald V. Lints* has joined the company.

RADIONICS INC., with *Dr. A. J. Stevens* as president and *Louis P. Farrell* as secretary-treasurer, is a new organization in the field of industrial applications of nuclear radiation. It will operate RADIATION ENGINEERED SERVICES as a division.

STATHAM INSTRUMENTS announces that *Gilbert N. Rosa* has been promoted to vice president and general manager.

G. N. ROSA
Statham

E. A. BIANCHI
Mason-Neilan

WORTHINGTON CORP. announces appointment of *Eric A. Bianchi* as general manager of the **MASON-NEILAN DIVISION.** Mr. Bianchi was also elected second vice-president of Fluid Controls Institute at its Spring Meeting in May.

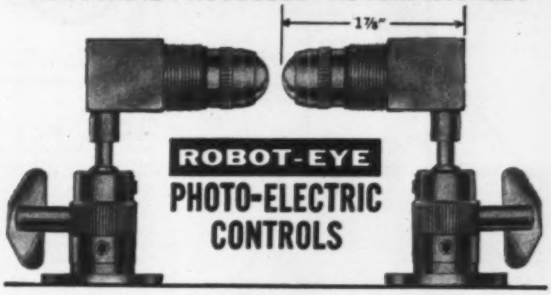
HUGHES AIRCRAFT CO. announces that *Gerhard L. Hollander* has been named manager of the newly formed general-purpose computer department.

DAYSTROM'S WESTON DIVISION announces that *Harold L. Russel* has been named product sales manager in charge of process instrument sales.

ROCKWELL MFG. CO. announces appointment of *C. H. Daugherty* as assistant manager-gas products for the Meter and Valve Div.

PACKARD BELL ELECTRONICS recently dedicated the first 53,000-sq-ft unit in a proposed 350,000-sq-ft facility in Newbury Park, Calif. This initial structure will house elements of the technical products division.

count, inspect, control
INDUSTRIAL PROCESSES—AUTOMATICALLY



ROBOT-EYE
PHOTO-ELECTRIC CONTROLS

Transistorized and Tube
AMPLIFIERS

Plug-in relays, receptacles for plug-in connection of lamps and cells. Additional Plug-in accessories include counters and time delays.

MINIATURIZED
Small, for "tight-spot" installation, yet **rugged** for long service. **Accurate,** for precise automatic control in virtually any industry.

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Entire assembly designed for prompt and easy installation. Now available at new low cost. Capacities 5, 10, 15 tons.

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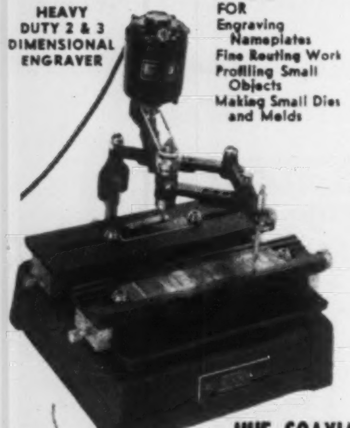

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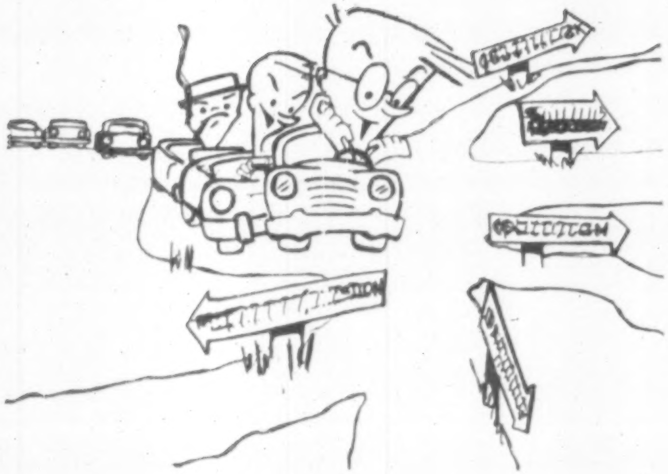

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11	31	51	71	91	111	131	151	171	191	211	231	251	271	291
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The following is a handy reference to products (and their reader-service number) reported in this issue. For more information on any product mentioned, circle the corresponding number on the reader-service card at the right.

This index is published as a service. Every care is taken to make it accurate, but I&CS assumes no responsibility for errors or omissions.

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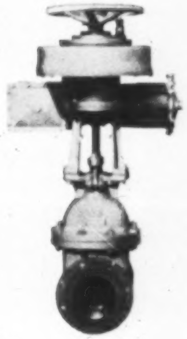

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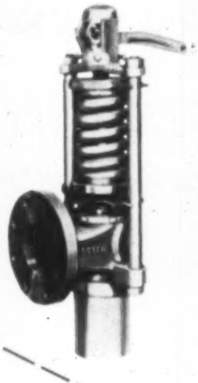

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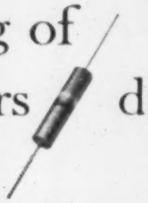

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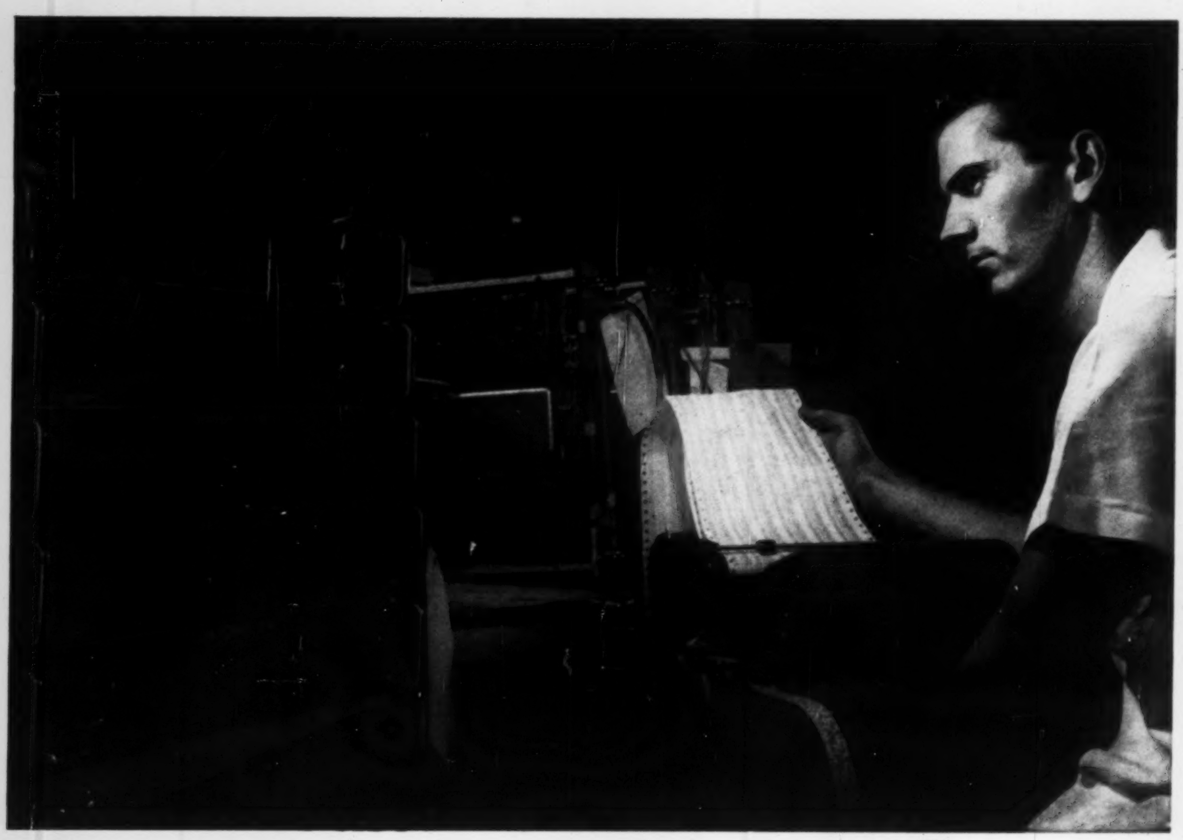

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